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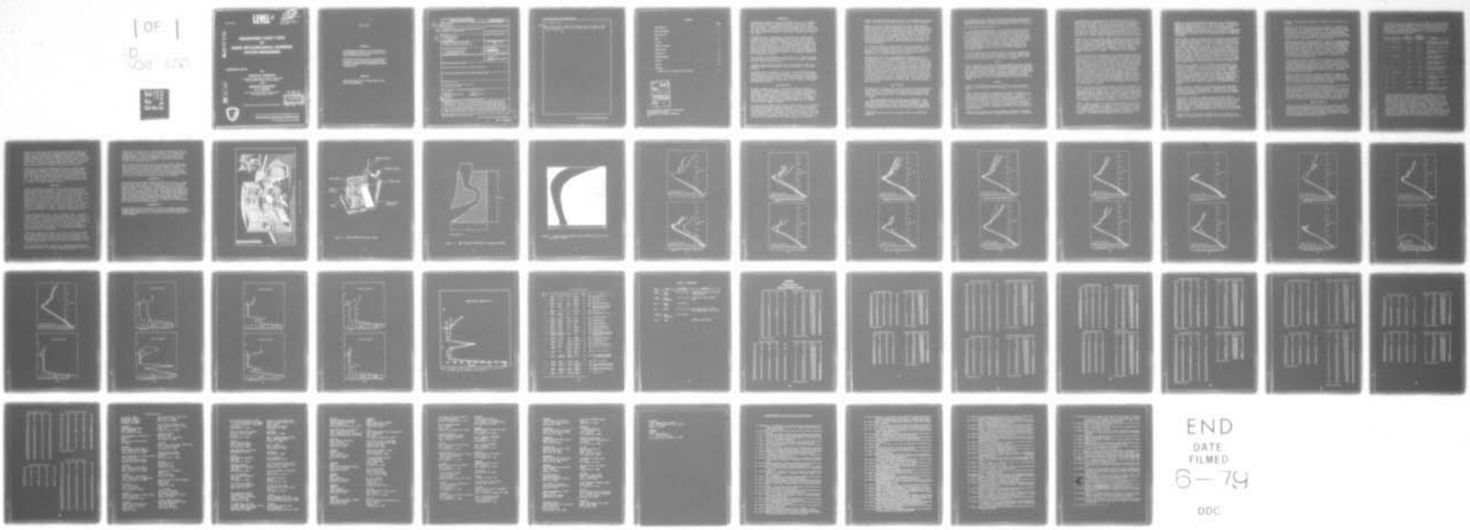

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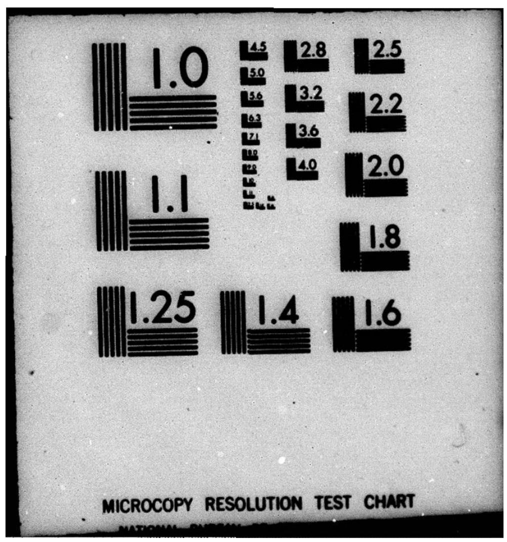
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ENGINEERING FLIGHT TESTS OF RANGE METEOROLOGICAL SOUNDING SYSTEM RADIOSONDE

FEBRUARY 1979

By

BRUCE W. KENNEDY

U.S. ARMY ATMOSPHERIC SCIENCES LABORATORY
White Sands Missile Range, New Mexico 88002

and

ARTHUR KINGHORN

B. R. HIXON

U.S. NAVY PACIFIC MISSILE TEST CENTER
Point Mugu, California 93043

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US Army Electronics Research and Development Command
Atmospheric Sciences Laboratory
White Sands Missile Range, NM 88002

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER (14) ERADCOM/ASL-TR-0022	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) ENGINEERING FLIGHT TESTS OF RANGE METEOROLOGICAL SOUNDING SYSTEM RADIOSONDE,		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) Bruce W. Kennedy, Arthur Kinghorn*, B. R. Hixon		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Atmospheric Sciences Laboratory White Sands Missile Range, NM 88002		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (16) DA TASK NO. 1L162111AH71
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Electronics Research and Development Command Adelphi, MD 20783	(11)	12. REPORT DATE Feb[redacted]79
		13. NUMBER OF PAGES 47 (12) 51p.
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

*US Navy Pacific Missile Test Center
Point Mugu, CA 93043

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Radiosonde
Atmospheric measurements
Temperature
Thermistor
Telemetry
Relative humidity
Hygristor

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Engineering flight tests of the Range Meteorological Sounding System (RMSS) radiosonde were conducted at Kwajalein Missile Range (KMR) during January and April 1978. The purpose of the program was to correct known deficiencies in the sonde and to test sensors and air ducts for accuracy and responsiveness. Fourteen modified and standard RMSS sonde releases were made. Results showed that the RMSS temperature sensor compares favorably with the National Weather Service rawinsonde. Humidity can be measured, but when insulation → next page

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and solar shielding are added to the package, results are improved. Operational problems were encountered with the RMSS sonde, and design deficiencies were discovered.

CONTENTS

INTRODUCTION

The Range Meteorological Sounding System (RMSS) (fig. 1) is an advanced tracking device designed to measure atmospheric parameters to a high degree of accuracy to meet high priority major range and test facility user requirements. Conceived by the Range Commanders Council Meteorological Group, the project was funded by the Navy, Army, and Air Force. The Navy Pacific Missile Test Center assumed project management and contractual control.

The RMSS consists of a ground-based tracking pedestal, automatic data processing computer, 403 MHz ranging transmitter, 1680 MHz telemetry receiver, and a newly developed radiosonde. During a typical mission a sonde is activated, attached to a meteorological balloon, released, and tracked by the ground station. A 403 MHz ranging signal is transmitted back to the ground station along with telemetry data on 1680 MHz. The sonde can monitor four sensors with a rapid, solid-state commutator and typically measure temperature and humidity in the standard configuration. Additional sensors can be added to measure other atmospheric parameters or for comparative purposes.

Data from sensors are displayed in near real-time on a graphics cathode ray tube (CRT), and are listed in tabular form on a printer. Postflight reduction also produces data plots.

The RMSS can also passively track National Weather Service (NWS) radiosondes and PWN8B/11A rocketsondes. Data are recorded on a strip chart recorder.

Acceptance tests of the RMSS were performed at Kwajalein Missile Range (KMR) during the period 16-27 January 1978. At that time the RMSS sonde was also flown in various research and development (R&D) configurations to test sensors and airflow ducts. This report describes the R&D flights, discusses results, makes recommendations on future sondes, and suggests additional test flights.

RMSS RADIOSONDE

The RMSS radiosonde (fig. 2) is a four-channel instrument capable of measuring any selected atmospheric parameter with electrical resistance transducers. In the standard configuration it contains a boom-mounted 10-mil bead thermistor and a duct mounted carbon element hygristor. Two spare channels are available for additional sensors such as pressure, ozone, and hygristor temperature, or standard sensors can be connected to the additional channels, thereby increasing sampling rate. Commutation rate is four frames per second.

The sonde receives ranging pulses with a 403 MHz receiver, and retransmits the range data along with telemetry information on a 1680 MHz downlink. All electronic components except the 1680 MHz transmitter are mounted on a single printed circuit (PC) board. The sonde is approximately 25.4 cm^3, weighs 900 grams, and is constructed of closed-cell styrofoam. The hygristor is mounded in an integral airflow duct, while the bead thermistor is attached to an outrigger boom. The 10-mil thermistor is soldered to a

silvered and aluminized mylar loop identical to the PWN8B Loki rocketsonde sensor. The bead is also aluminized to reduce solar radiation heating.

Typically, the sonde is bench tested with an external power supply to adjust ranging and telemetry frequencies and to test sensor performance. Overall sonde and ground station performance is also checked; then a water activated battery replaces the external power supply, the hygristor element is mounted in the duct, and the cover is installed. Sensor performance is again observed on the graphic display. Three nylon cords are wrapped around the styrofoam container to secure the cover, and a four-cord rigging harness is attached. The activated sonde is carried to an elevated platform where baseline computer functions are performed and range bias determined.

The sonde is attached to a meteorological balloon and released. Tracking is automatic during the entire flight, and near real-time data can be observed on both graphics display and in tabulated form. The CRT also displays a plot of relative sensor value as a function of altitude, a convenient way to detect abnormal sensor function.

An integral air duct (fig. 3) which houses the humidity element is a miniaturized version of the NWS NEXAIR duct.* Flow characteristics of the RMSS humidity ducts were made by Messrs M. Krumins and E. Fisher in the US Naval Academy wind tunnel. The results gave rise to hopes of measuring ambient air temperature in the duct near the humidity sensor; thus protecting the fragile 10-mil bead thermistor from damage. Improvements in flow and a decrease in turbulence were detected when the entrance orifice was tilted at a negative 35-degree angle in the wind tunnel. This prompted new design models, and one particular configuration, referred to as Krumins C3 (fig. 4), was found to have excellent flow pattern and very low turbulence in the duct. Reproductions of the C3 duct were made and were included in the R&D test program at KMR. The conclusion was that improved flow would benefit both temperature and humidity measurement in the duct.

KMR TEST PLAN

Representatives of the Army, Navy, and Air Force met in Phoenix, Arizona, in December 1977, and devised a plan to perform R&D tests on the RMSS sonde. At KMR the tests would be in conjunction with acceptance tests of the RMSS during January 1978. The overall sonde problem was stated as follows:

"The current RMSS radiosonde has two major deficiencies. First, the temperature sensor, a 10-mil bead thermistor attached to a loop mount on an extended boom, is very fragile and susceptible to breakage from mishandling and severe weather. Second, the air duct containing the humidity element is known to have poor airflow characteristics and

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*Personal discussions with Bruce Bollermann, Space Data Corporation, Tempe, AZ.

is susceptible to solar radiation [electrical] and battery heating effects. It is highly desirable to eliminate the boom and loop mount by moving a thermistor inside the duct providing temperatures are proved to be equal."

The test approach read as follows:

"A minimum of ten RMSS sondes will be required to make engineering changes and perform flight tests. The changes will be minor, and most of them will be done on site at KMR. Space Data Corporation will provide the existing sonde with the following changes: the hygristor mount will be modified to place it in the best airflow location and to isolate it from battery and printed circuit board heat. Opaque material will be placed around the duct walls (outside) to shield the interior sensors from solar radiation. Waxed cardboard or similar material will be placed in the battery cavity to prevent acid damage. Suitable drain holes will be drilled in the styrofoam case to permit drainage of excess battery water."

The basic configuration was changed on site to measure heat conduction to the hygristor, detect flow and turbulence in the duct, measure solar influence, and determine hygristor temperature. Survival tests, particularly in rain, were planned, but nature did not cooperate.

TESTS

Table 1 summarizes the standard and R&D sonde flights that were conducted at KMR. Twenty-two balloon ascents with RMSS radiosondes were made, most with a conjunctive NWS radiosonde. Fourteen of the ascents were dedicated R&D tests, and eight were standard releases. Occasionally, an extra sensor was placed on a standard flight for comparative purposes. The standard configurations were flown for the purpose of acceptance tests on the complete RMSS system. Table 2 lists the sensors used during the R&D test flights.

RESULTS

Flight 0 was a standard configuration released for initial checkout purposes. Timing problems in the incoming line prevented retrieval of data.

Flight 1 (fig. 5) was also a standard sonde, except the hygristor contained a bead thermistor for temperature measurement. Agreement between air temperature, as measured by the loop mount, and the hygristor thermistor was within 4°C up to 14 km, then diverged significantly to a 28°C difference at 35 km. Increases in relative humidity (RH) up to 40 percent were detected above 10 km, but it is not known how meaningful the values are. Therefore, inaccuracies in temperature of the hygristor with respect to air are not considered significant in the computation of relative humidity.

Flights 2 and 3 (figs. 6 and 7) were designed to measure the difference in duct wall temperature with and without cork insulation. In addition,

air temperature was measured with the loop mount on its boom, duct temperature with a post-mounted 10-mil bead thermistor. A second duct was attached side saddle to the sonde and also contained a 10-mil post-mounted bead thermistor. Cork (6 mm thick in two plies) was glued to the battery compartment wall between the battery and duct. Results were positive. The cork decreased duct wall temperature by 9°C at 25 km, but only a 2°C improvement was seen in the duct temperature at 25 km. The added duct, however, measured temperatures that were cooler than the standard duct. Neither, however, compared favorably with the loop mount.

Flight 4 (fig. 8) was a standard sonde, except that the angle of attack of the duct was -35 degrees. This angle was determined by Krumins and Fisher in wind tunnel tests which improved the flow through the standard duct. The temperature difference between the hygristor thermistor and the loop mount at 25 km was 21°C, as opposed to 13°C on flight 1. The change in angle of attack, in fact, degraded the airflow, allowing thermal contamination of the sensor. The reason will be discussed later.

To further evaluate the standard duct for measuring atmospheric temperature, a sonde was flown at -35 degrees angle of attack, and 10-mil bead thermistors were placed in the duct inlet and at the optimum flow region in the duct throat. An additional standard duct attached to the sonde also contained a 10-mil bead in the throat region. Solar shielding was used on the attached duct. Flight 5 (fig. 9) shows the results of this test. The important discovery here was that all sensors in the ducts exhibited large oscillatory excursions above 20 km. There was also significant divergence of the standard duct inlet and throat thermistors from the loop mount above 20 km. Even though the add-on duct appeared to agree more favorably with the loop mount, personal observation of the graphics display revealed unacceptable temperature excursions. Figure 9 is plotted at 1-km intervals, which causes aliasing and is the reason for the apparent better agreement. Close scrutiny of the 1 km data showed a warm-side bias of 2.4°C between 20 to 22.5 km and 2.8°C between 27 to 30 km.

Flight 6 (fig. 10) was an abortive attempt to evaluate the Krumins C3 duct. Sonde problems caused channel dropouts during the flight, so the test was repeated in flight 8 (fig. 11). Channel 2, the C3 duct inlet temperature, went bad before launch. Channel 3, an add-on standard duct with 10-mil bead, and channel 4, the C3 duct containing a 10-mil bead, were flown at angles of -35 and -45 degrees, respectively. The results were conclusive: neither the standard duct nor the Krumins model accurately measured air temperature. Divergence was severe above 20 km.

Flight 7 (fig. 12) tested the ability of the standard duct and the C3 duct to measure humidity. As a point of interest, the temperature of each humidity element was also measured. The standard duct was flown at 0 degrees angle, while the C3 version was at -45 degrees. Between the surface and 5 km, the two hygristors measured virtually the same humidity. A conjunctive NWS radiosonde showed comparable data.

Between 5 to 10 km, the differences were greater than 4 percent; and above 10 km, differences were on the order of 8 percent. The hygristor thermistors offered another picture. There was excellent agreement in temperature between the surface and 25 km, and the standard duct temperature diverged to the warmer side. At 32 km the C3 duct hygristor temperature was 6°C colder than the standard duct hygristor temperature. This difference, however, was of little significance in the measurement of humidity.

Flights 9 and 10 (figs. 13 and 14) offered an examination of a different type of sensor, a 55-mil bead thermistor. The beads were mounted to metal standoff posts similar to the 10-mil thermistors used in previous R&D flights and were attached to a boom which protruded from the side of the sonde. Flight 9 was in daylight, and 10 was in darkness. Each bead was coated with white enamel paint to reduce solar radiation influence. Flight 9 showed a definite divergence between loop mount and 55-mil bead sensors, with the 55-mil bead yielding warmer temperatures above 20 km. This difference was caused primarily by solar radiation. Flight 10, however, showed divergence in the opposite direction, with the 55-mil thermistor reading colder above 20 km. Most of the difference was attributable to lag and radiation cooling, and the two flights give an understanding of solar radiation and lag in the 55-mil bead.

Flight 11 was a diagnostic test to determine the temperature of the commutator during flight. Several previous sondes had been plagued with loss of channels in the vicinity of the tropopause. Temperature influence was suspected, but this flight showed that the commutator temperature varied between only about 20° and 25°C. Later consultation among factory representatives at KMR and in Phoenix revealed that battery condensation probably caused short circuits on the PC board. It was suggested that an overcoat of silicon grease be swabbed on the PC board. This technique proved to be very successful, and later sondes, starting with flight 15, subjected to the procedure were successful.

Flight 12 (fig. 15) compared the loop-mounted bead thermistor with a post-mounted bead. Both were located on the same boom. The post-mounted bead measured air temperature to within 2°C of the loop bead throughout the flight, suggesting that a bias error existed, probably in the calibration data.

Flight 13 (fig. 16) was an attempt to evaluate several types of thermistors. All sensors were boom mounted and coated white for solar reflectivity. The loop bead was aluminized as in all previous tests. Again, sonde electronic problems were encountered (the silicon fix technique had not yet been postulated), but results were still obtained. Channel 2, a 75-mil thermistor was warmer than the loop bead by 8°C at 28 km. An NWS wafer sensor was 9°C warmer, and a 55-mil bead was 6°C warmer.

Flight 14 (fig. 17) contained a standard duct and a C3 duct on 5 cm standoffs. The purpose was to isolate the ducts from the sonde with an

airspace. Results were inconclusive. Channels 2, 3, and 4 quit at 20 to 21 km.

Flight 17 (fig. 18) was the last R&D test in January. A standard duct was mounted on 5 cm standoffs and contained 10-mil beads in the throat and the inlet. The loop-mounted bead was flown on its boom, and an NWS rod thermistor was mounted on the sonde by its outrigger framework. The balloon burst at 19.2 km; however, temperatures started to diverge at about 13 km. Both duct thermistors and the rod read warmer at 16 km, and maintained the differences at balloon burst point.

Additional R&D tests of the RMSS sonde were conducted on 6 April 1978. The first flight (fig. 19) was designed to compare a loop-mounted 10-mil bead thermistor, a post-mounted 10-mil bead thermistor, and an NWS rod thermistor on a standard sonde. Unfortunately, the wrong calibration data were introduced into the computer for channel 2, the post mount, which resulted in erroneous data. During this flight the loop-mounted bead and the rod temperature agreed between the surface and 2 km altitude; then the two sets of data diverged to a constant 3°C with the rod thermistor reading warmer.

Flight 20 was an attempt to compare relative humidity as measured in the standard duct and a standoff duct. The RMSS sonde was placed beside an NWS radiosonde on the same balloon train, and there was radio frequency interference between the two even though the NWS sonde transmitted at 1690 MHz and the RMSS sonde was at 1662 MHz. The interference was detected only on the RMSS ground equipment, not on the AN/GMD-1 (GMD) tracking the NWS sonde.

Flight 21 (fig. 20) compared a hygristor mounted in a standoff duct with one mounted in an NWS duct that was strapped to the RMSS sonde. Temperature of both hygristors was measured. Even though the balloon burst at 13 km, all pertinent data had been collected. Temperature and relative humidity were nearly identical at all levels.

Flight 22 (fig. 21) compared a loop mount, post mount, and rod thermistors during a nighttime release. There appeared to be a 2- to 3-degree bias between the loop- and post-mounted thermistors, a condition that prevailed throughout the flight. This condition is attributed to calibration error. A bias also existed between the loop and the rod, but the magnitude slowly diminished with altitude. Initially, a 6°C difference existed, with the rod reading warmer; but near burst, near 38 km, the bias was only 2°C, again with the rod reading warmer.

RELATIVE HUMIDITY

Flights 2 and 3 measured the difference in wall temperature between the standard duct without and with cork insulation. As would be expected, the cork reduced the wall temperature varying from 2°C at 1 km altitude to 14°C at 10 km. There was also a significant difference in duct air temperature between the two flights which would, of course, affect the computation of relative humidity.

To find out which duct configurations were the best for humidity measurements, RMSS sondes were compared to the nearest NWS conjunctive rawinsonde release. Differences were taken at 1 km levels up to 13 km or the upper limit of the rawinsonde humidity data. The differences were then averaged and standard deviations computed. The following chart shows the comparison (neglecting signs).

Order	Flight No.	Mean Difference	Standard Deviation	Remarks
1	7 (ch 1)	0.38	6.3	Standard duct, with cork and cardboard solar shield
2	21 (ch 3)	1.0	8.9	J005 duct on RMSS sonde
3	9	1.15	6.15	Standard duct with cork and cardboard
4	21 (ch 1)	1.3	9.1	Standoff standard duct with cardboard
5	1	1.85	2.12	Standard duct without cork, cardboard
6	10	-3.25	7.37	Standard duct, without cork, night flight
7	7 (ch 3)	8.6	15.15	C3 duct at -45 deg
8	19	-8.62	8.79	Standard duct, no cork or cardboard
9	12	14.46	3.95	Standard duct, no cork or shielding
10	4	18.46	4.9	Standard duct, -35 deg, no cork or shielding

One could conclude that the addition of cork insulation and solar shielding effectively improved the measurement of humidity. However, flight 1 (fig. 22) was flown without these modifications and still yielded results that were comparable with the NWS rawinsonde. This occurrence can probably be attributed to the tightness of fit between the styrofoam duct and the battery compartment. These parts were hand-cut, and hand-assembled. Therefore, there were slight differences in fit among the sondes that were flown. Perhaps the sonde used on flight 1 fitted snugly and sealed the air leaks between the battery case and air duct. Conversely, flight 4 (fig. 23) shows a large disagreement between the standard sonde and the NWS rawinsonde. In this test, cork and shielding were not used, but the duct was tilted at -35 degrees.

Figures 24 through 29 show additional comparisons between humidity as measured by various RMSS sonde configurations and the NWS rawinsonde. In most cases, the NWS sonde was released within minutes of the RMSS, thereby reducing time and space variability problems. Flights 19 and 21 (figs. 28 and 29) were exceptions. Flight 19 was released 3 hours after the NWS sonde (both were morning flights), while flight 21 was flown 2 hours after a conjunctive rawinsonde (both were afternoon releases). Some variability can be attributed to time and space separation.

Flight 21 was of particular significance because it measured humidity with elements contained in both an RMSS duct mounted on insulating standoffs and in an NWS duct mounted to the side of the RMSS package. The standoff duct was completely covered with opaque cardboard to prevent solar radiation from penetrating through the styrofoam into the duct. As figure 29 shows, the two humidity profiles are nearly identical. Even though this is a sample of one, it adds credibility to the performance of the RMSS standard duct design.

OBSERVATIONS

In this discussion of test results a few words are appropriate about factors that influence performance. Even though wind tunnel tests showed improved flow at different angles of attack and in optimum configurations, the real world is not a tunnel. During one flight, a Super Radot, a precise optical tracker at KMR, recorded over an hour of balloon ascent. The train, which included the sonde and a 12.7 cm aluminum sphere, oscillated like a pendulum. The path of the swing appeared to be elliptical with a period of 6.5 seconds per cycle. In addition, the sonde spun about the string axis giving a very complicated flow pattern throughout the flight. The swing obviously caused the oscillatory temperature on flight 5 and others, and probably contributed to the overall failure to accurately measure air temperature in the duct.

The human engineering aspect is also an important factor. The sonde assembly procedure was tedious and time-consuming. Battery assembly required removal of part of the standard duct assembly. The battery was in the electronics compartment and the moist acid effluent caused PC board malfunctions. The boom on which the loop mount was placed did not have an adequate support and had to be taped for added strength. In short, not much thought was given to the operational requirements for prelaunch preparation and handling. Future designs must diligently pursue this aspect of sonde utility.

The NWS J005 radiosonde was flown in conjunction with most of the KMR test flights, and plots are shown in this report for comparative purposes. The J005 suffered from slow commutation rate and tended to lose some amplitude resolution. Temperature was in good agreement. Above 20 km studies by Ballard and Rubio* show that both solar radiation and lag

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*H. N. Ballard and R. Rubio, "Corrections to Observed Rocketsonde and Balloonsonde Temperatures," Journal of Applied Meteorology, October 1968.

conditions exist with the rod. Why then should the rod agree with the 10-mil bead? A probable cause is the inaccuracy of the pressure sensor in the NWS sonde. Pressure altitude errors of up to 5 km have been measured which will cause a misassignment of the temperature versus altitude, and hence an apparent temperature difference. Perhaps the problem is more difficult than that.

Tests 19 and 22 indicate that, except for biases, daytime comparisons between rod and bead are favorable, while at nighttime there are significant differences. On flight 19, a daylight flight, the average temperature difference between the bead and rod (b-r) is -2.1°C below 20 km, and -2.3°C above 20 km. Flight 22, a nighttime release, shows -4.8°C difference below 20 km and -2.7°C above. The primary differences are the solar radiation and the nighttime long wave radiation.

CONCLUSIONS

Three main points concerning the RMSS radiosonde can be made as a result of these test flights. First, air temperature cannot be accurately measured in either the standard duct or the Krumins C3 duct at different angles of attack, or on standoffs. Second, humidity can be measured in the standard duct, with insulation, with solar shielding, and comparable with but more frequently than NWS sondes. Temperature measurement of the hygristor should be continued until total error budget can be determined. Third, the loop-mount bead thermistor measures air temperature more accurately and more frequently than the NWS rod thermistor. However, it appears that the more expensive loop can be replaced with the less expensive post-mounted 10-mil bead thermistor

RECOMMENDATIONS

Extensive RMSS radiosonde flight tests should be conducted to determine optimum sonde housing configuration, sensors to be used and their placement, optimum sensor sampling rate and smoothing techniques, and accuracies of the measurements.

Figure 1. RMSS control console and tracker.

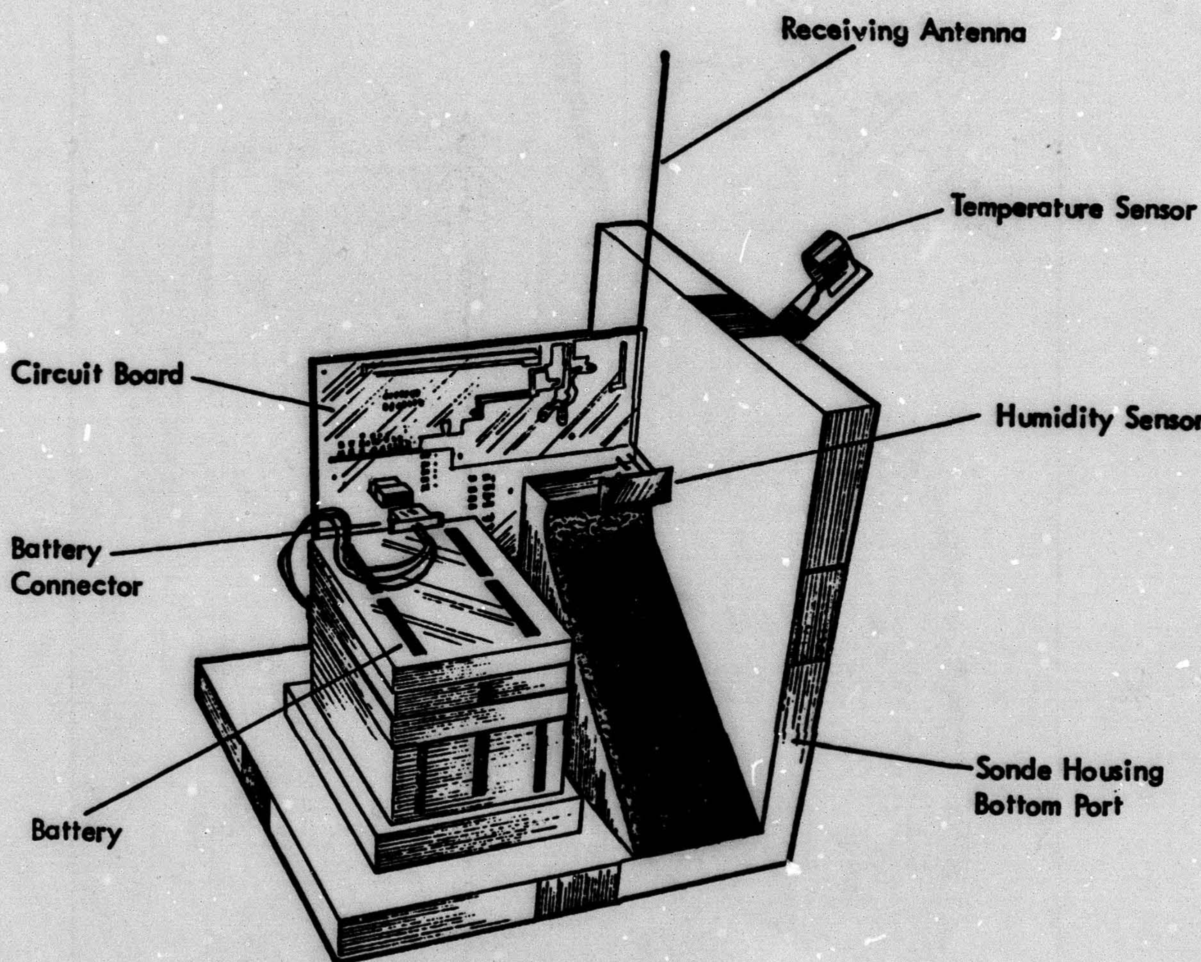
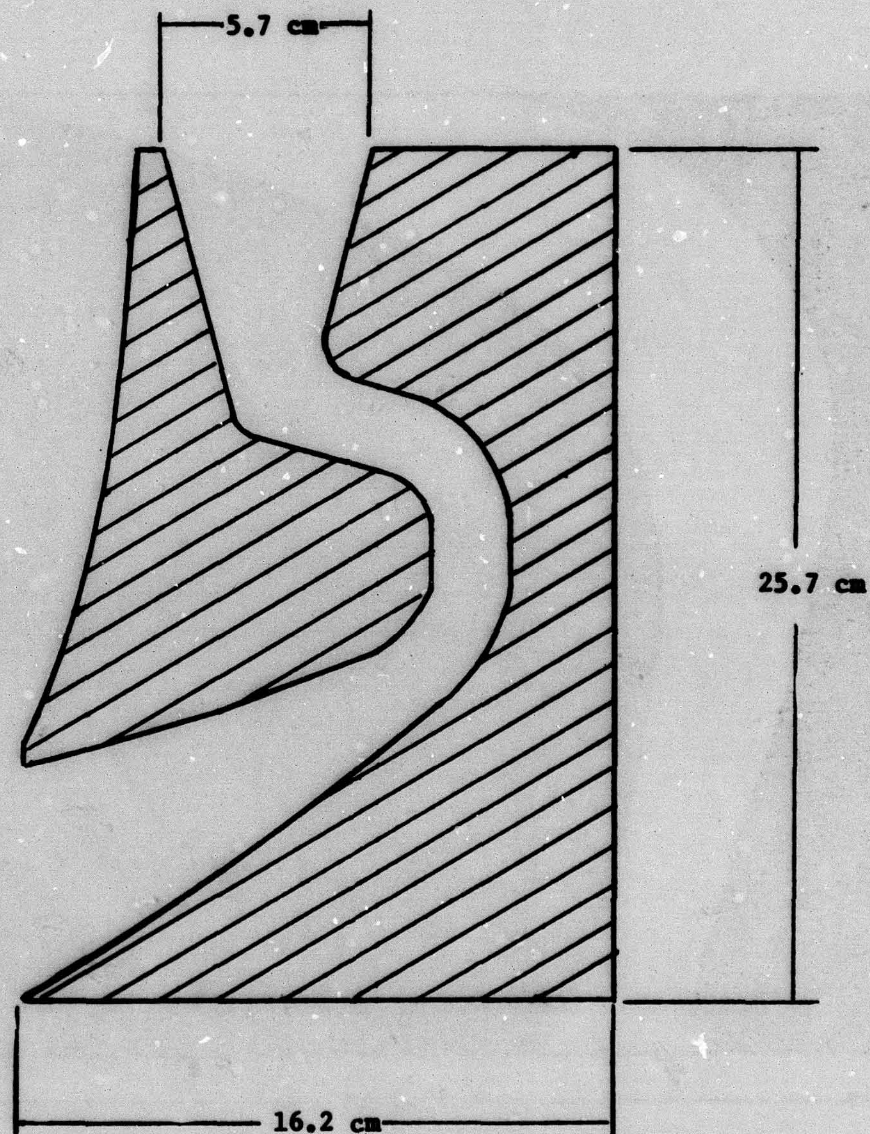


Figure 2. RMSS radiosonde with cover removed.



DUCT WIDTH 7 cm

Figure 3. RMSS radiosonde standard duct for hygristor element.

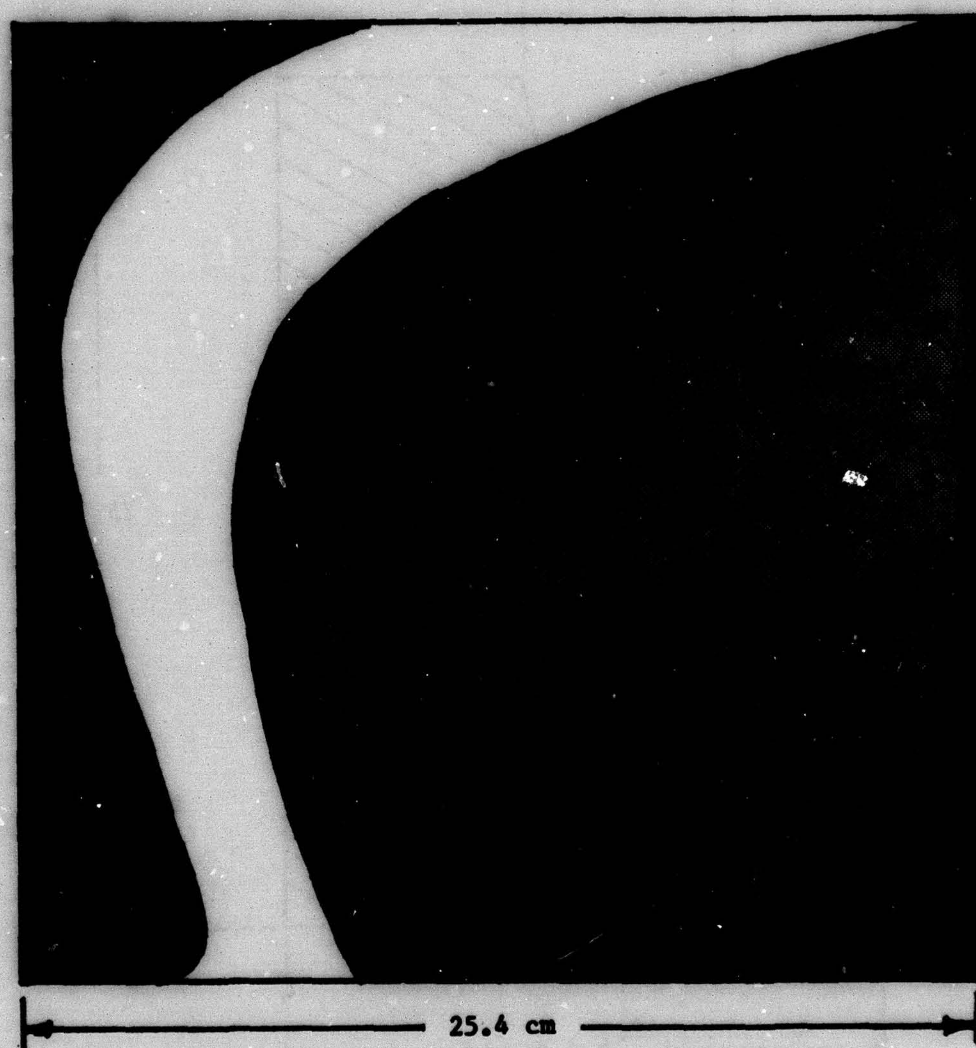


Figure 4. Cross section of Krumins-Fisher configuration three (C3) duct for hygristor element.

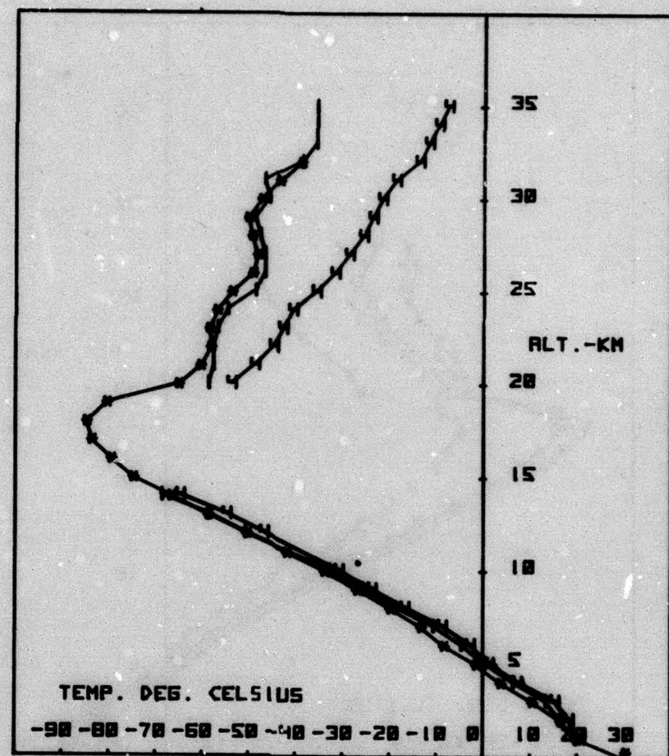


Figure 5. Flight 1; 1-loop mount; 4-hygristor thermistor; *-NWS rawinsonde.

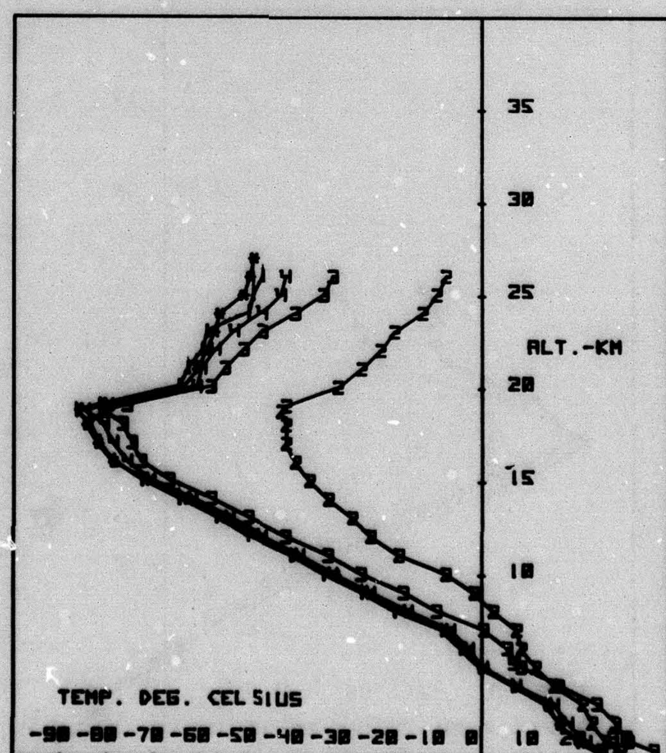


Figure 6. Flight 2; 1-loop mount; 2-standard duct wall temperature; 3-standard duct air temperature; 4-add-on standard duct air temperature; *-NWS rawinsonde.

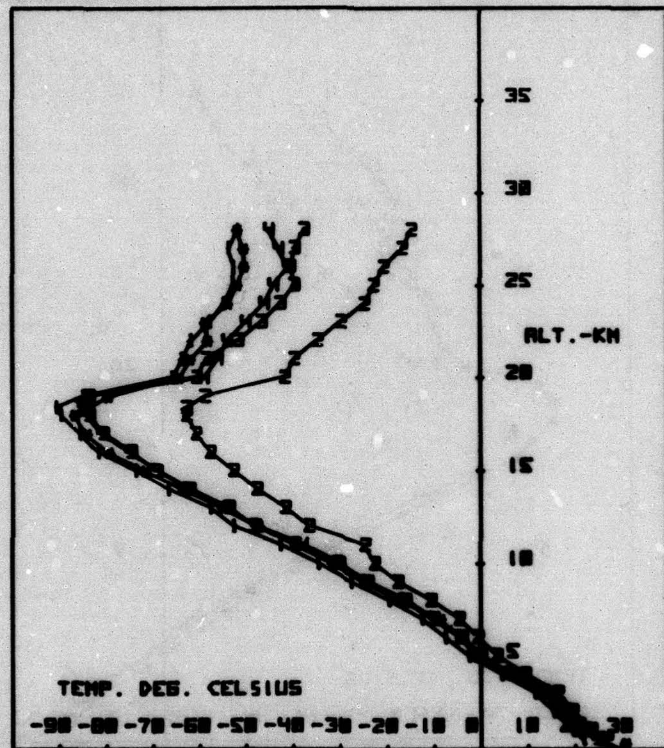


Figure 7. Flight 3; 1-loop mount; 2-standard duct wall temperature; 3-standard duct air temperature; 4-add-on standard duct air temperature; *-NWS rawinsonde.

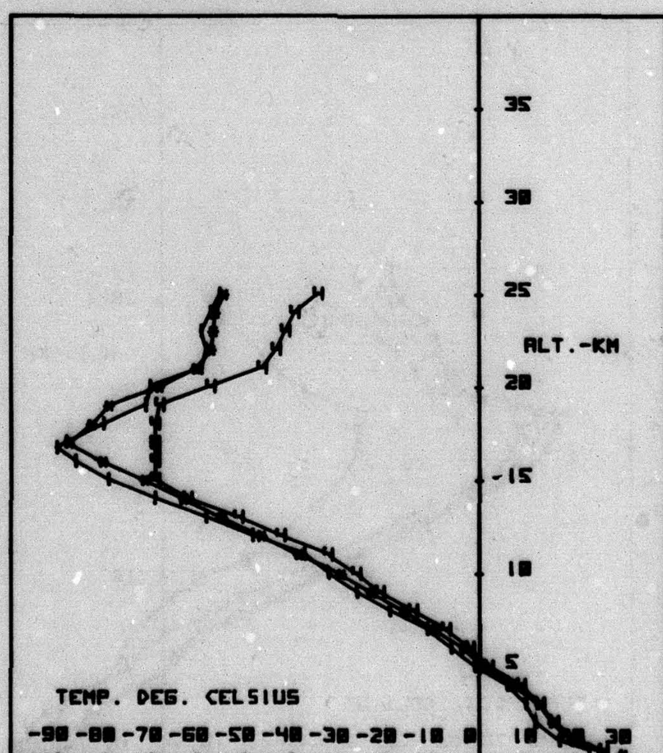


Figure 8. Flight 4; 1-loop mount; 4-hygristor thermistor; *-NWS rawinsonde.

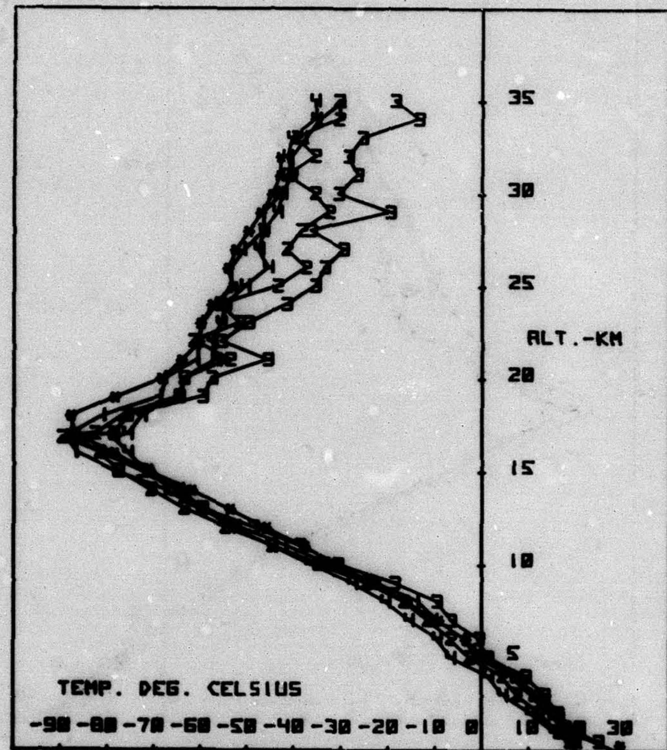


Figure 9. Flight 5; 1-loop mount; 2-thermistor at standard duct entrance; 3-standard duct air temperature; 4-add-on standard duct air temperature; *-NWS rawinsonde.

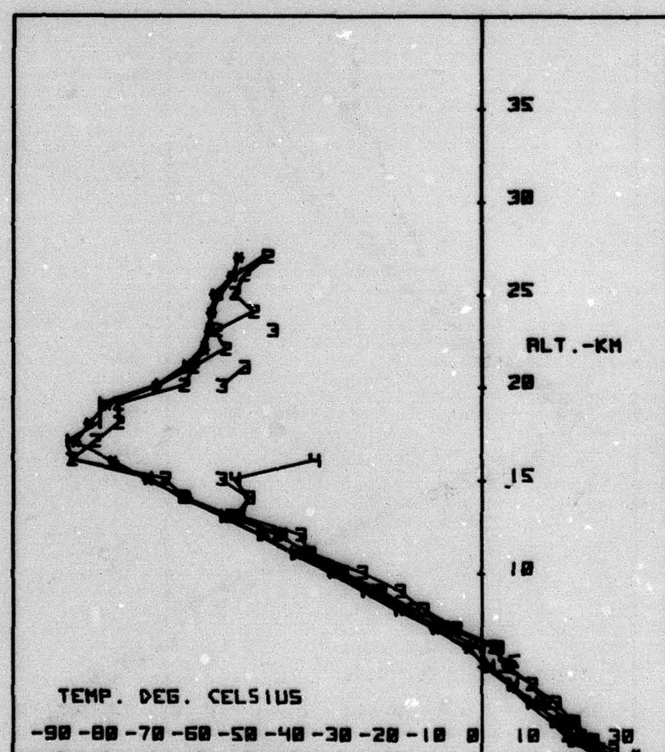


Figure 10. Flight 6; 1-loop mount; 2-C3 inlet thermistor; 3-standard duct air temperature; 4-C3 duct air temperature; *-NWS rawinsonde.

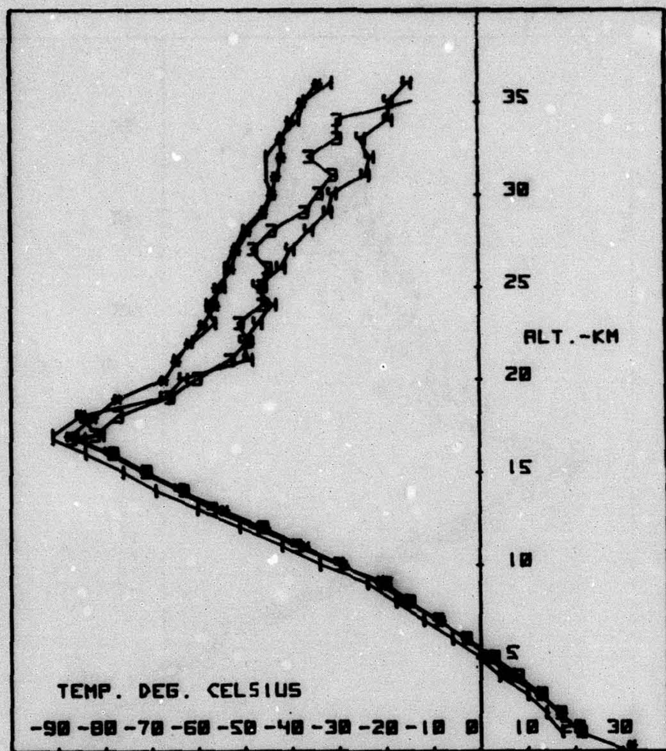


Figure 11. Flight 8; 1-loop mount; 2-C3 inlet thermistor; 3-standard duct air temperature; 4-C3 duct air temperature; *-NWS rawinsonde.

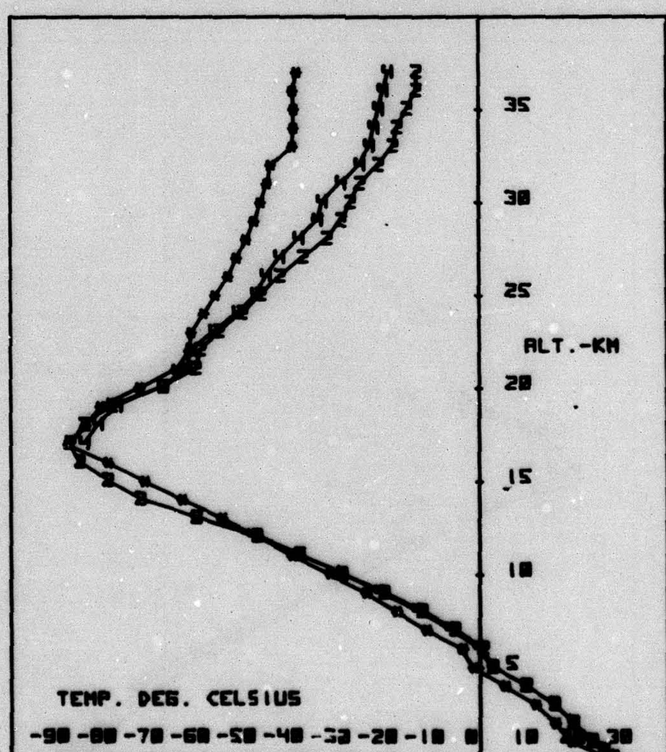


Figure 12. Flight 7; 2-hygristor thermistor in standard duct; 4-hygristor thermistor in C3 duct; *-NWS rawinsonde.

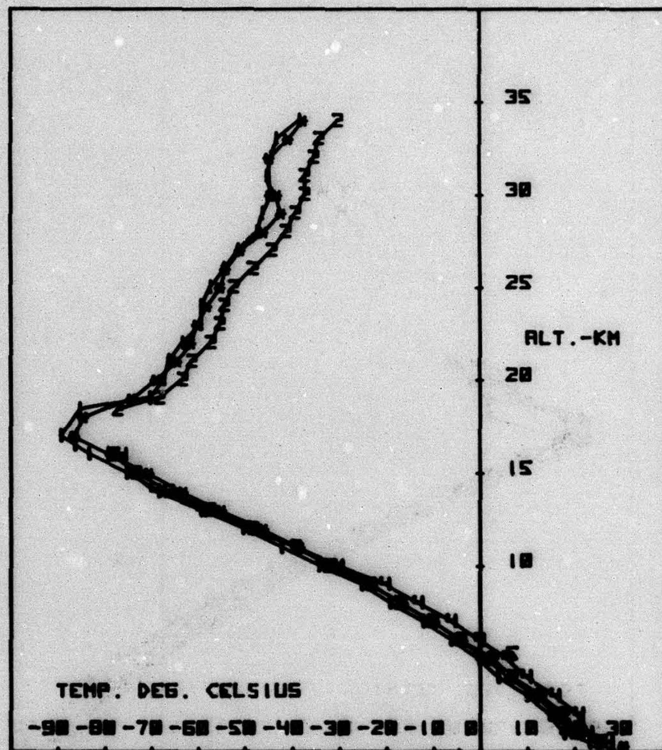


Figure 13. Flight 9; 1-loop mount; 2-YSI thermistor on boom; 4-hygristor thermistor; ^-NWS rawinsonde.

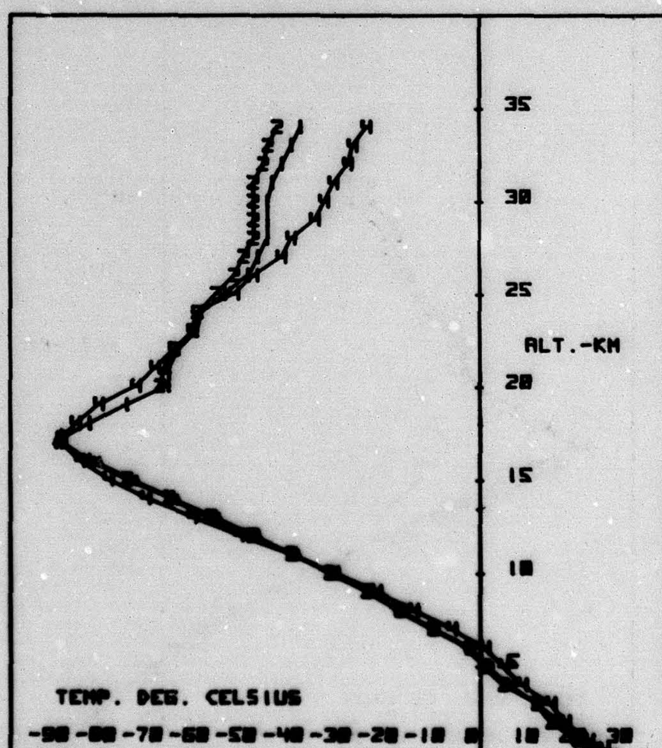


Figure 14. Flight 10; 1-loop mount; 2-YSI thermistor on boom; 4-hygristor thermistor; ^-NWS rawinsonde.

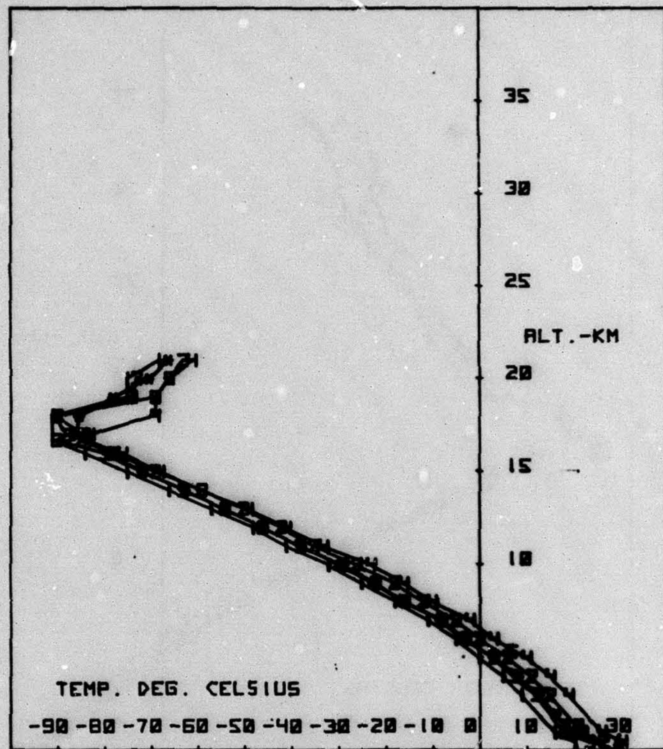


Figure 15. Flight 12; 1-loop mount; 2-post mount on boom; 4-hygristor thermistor; *-NWS rawinsonde.

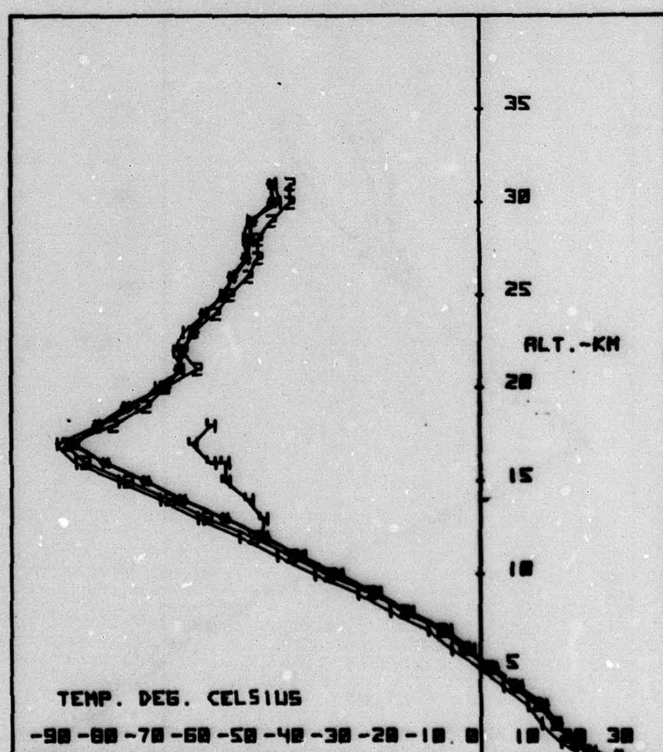


Figure 16. Flight 13; 1-loop mount; 2-Sensi-chip on boom; 3-wafer thermistor on boom; 4-Western thermistor on boom; *-NWS rawinsonde.

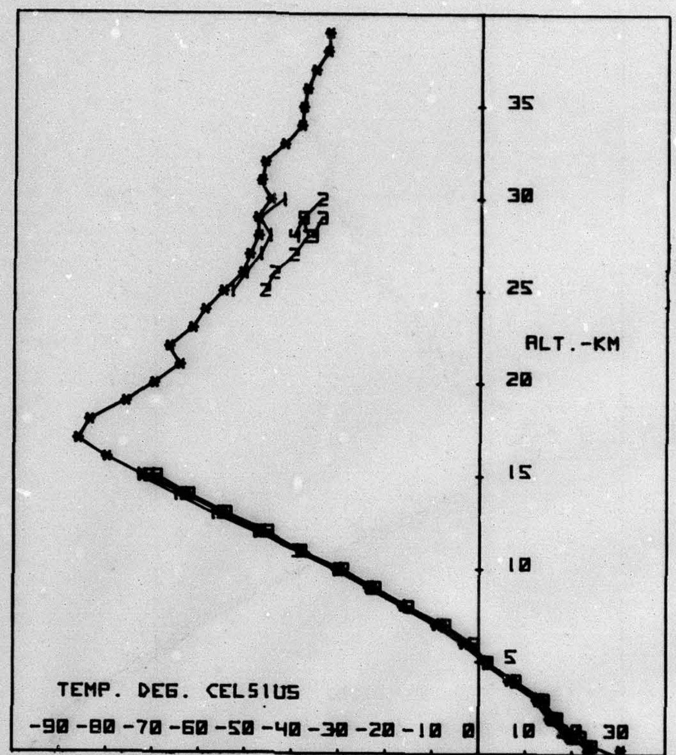


Figure 17. Flight 14; 1-loop mount; 2-standard duct air temperature; 3-standoff standard duct air temperature; 4-standoff C3 duct air temperature; *-NWS rawinsonde.

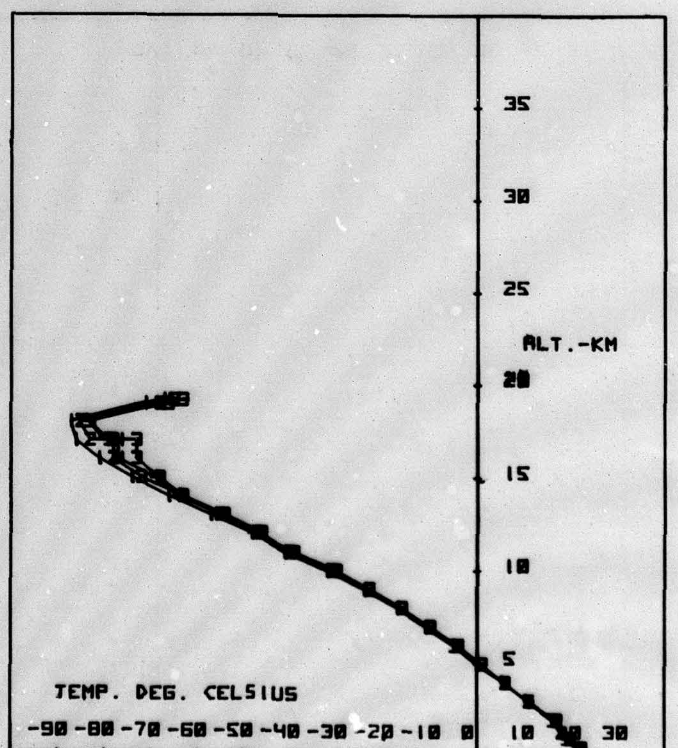


Figure 18. Flight 17; 1-loop mount; 2-standoff duct air temperature; 3-standoff duct inlet temperature; rod thermistor.

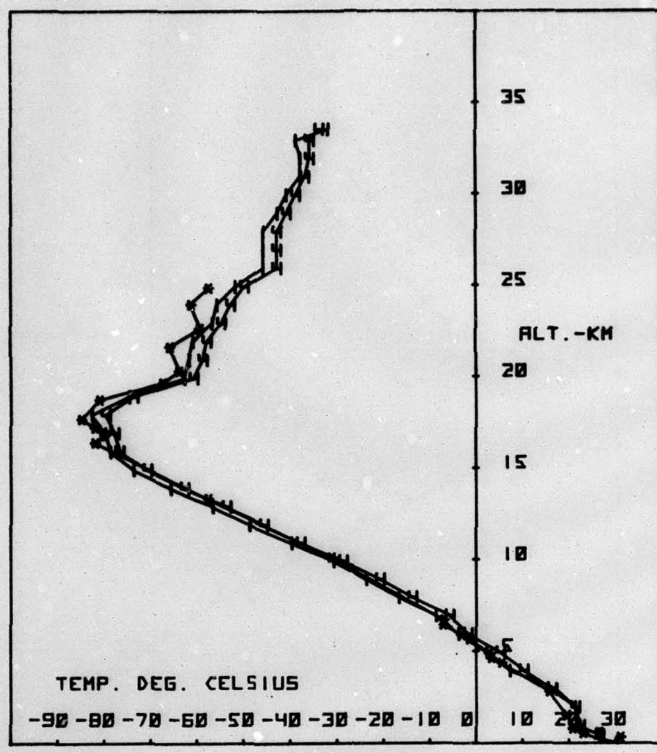


Figure 19. Flight 19; 1-loop mount; 4-rod thermistor; *-NWS rawinsonde.

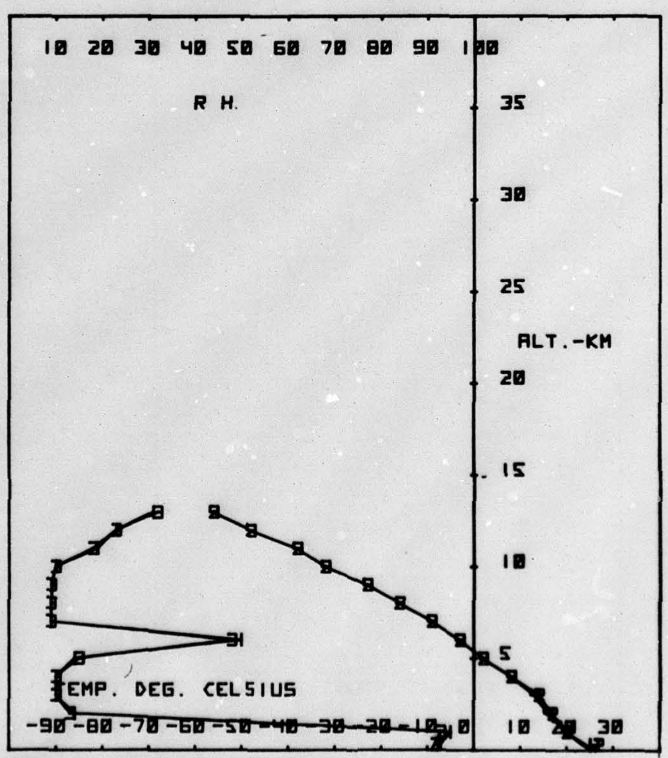


Figure 20. Flight 21; 1-hygristor in standoff duct; 2-hygristor thermistor in standoff duct; 3-hygristor in J005 duct; 4-hygristor thermistor in J005 duct.

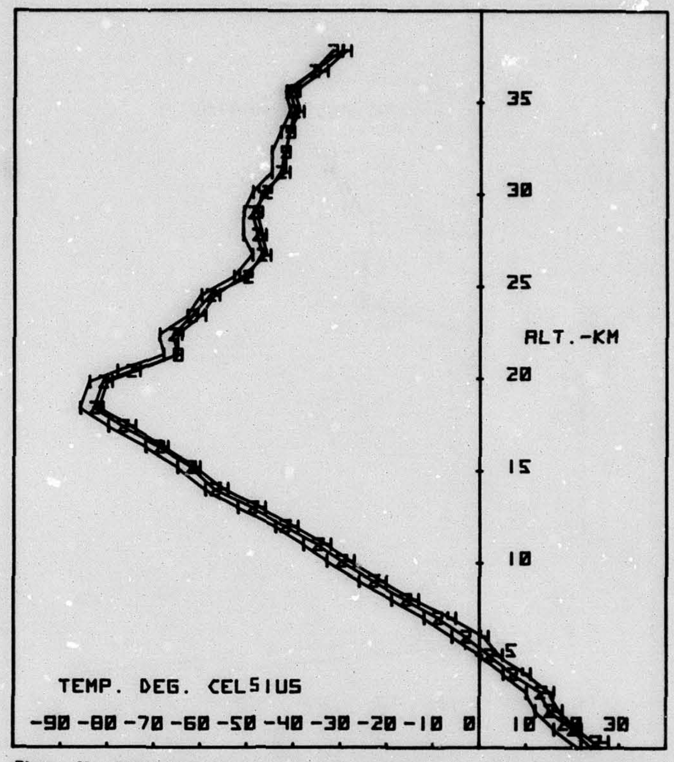


Figure 21. Flight 22; 1-loop mount; 2-post mount thermistor; 4-NWS rod thermistor.

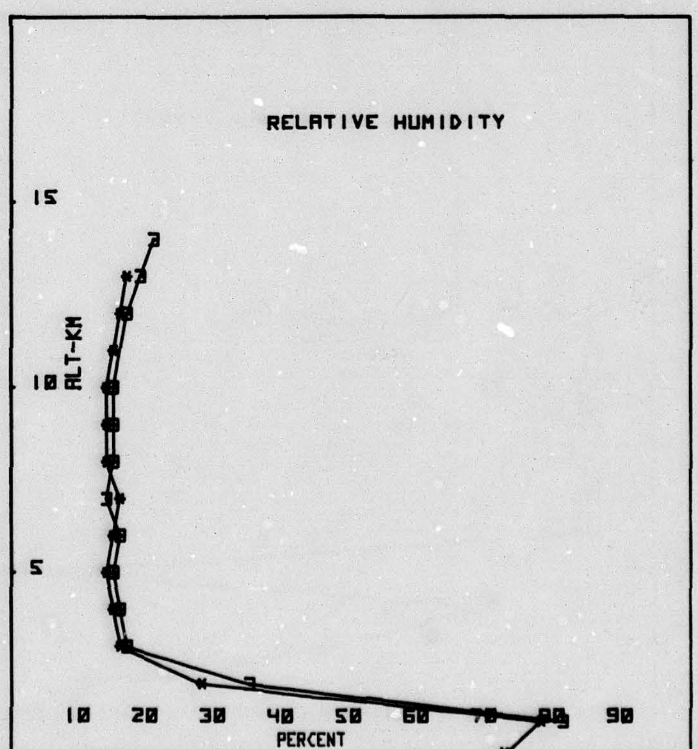


Figure 22. Flight 1; *-NWS rawinsonde; 3-NMSS sonde standard duct.

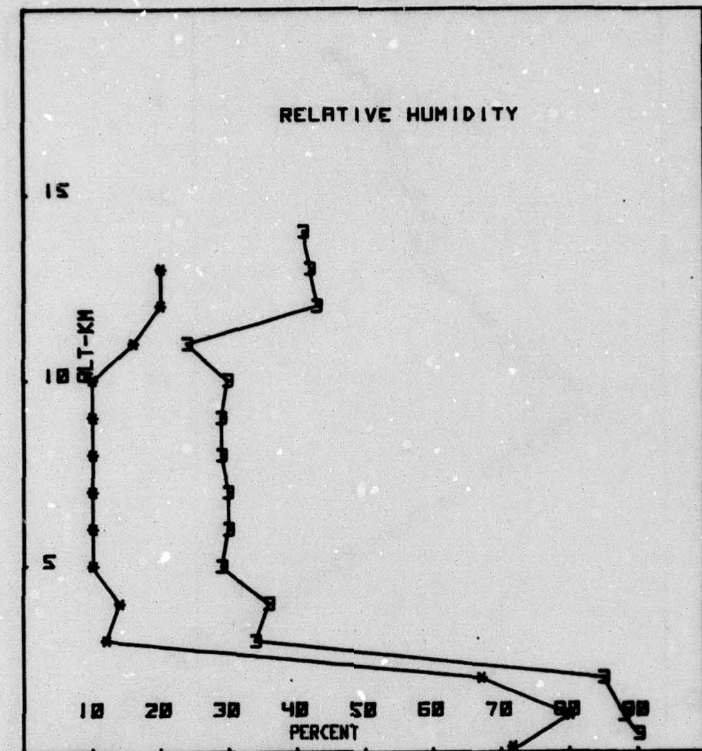


Figure 23. Flight 4; *-NWS rawinsonde; 3-NMSS sonde standard duct at -35 deg angle of attack.

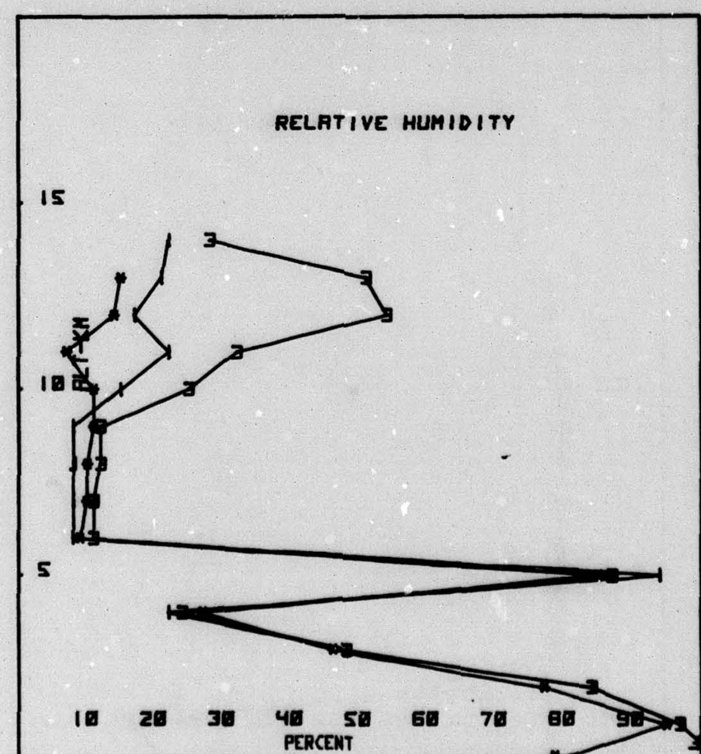


Figure 24. Flight 7; *-NWS rawinsonde; 1-NMSS standard duct with cork and cardboard; 3-C-3 duct tilted at -45 deg.

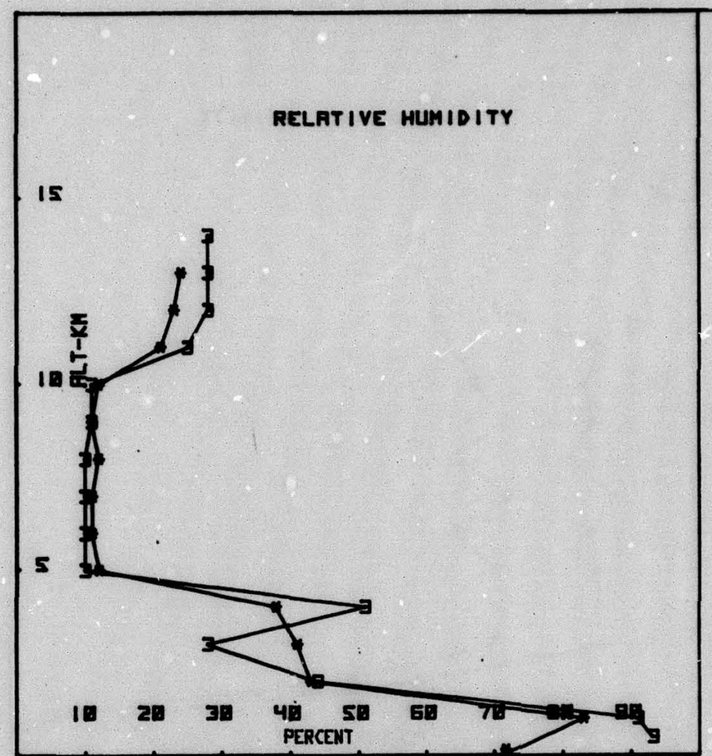


Figure 25. Flight 9; *-NWS rawinsonde; 3-NMSS standard duct with cork and cardboard.

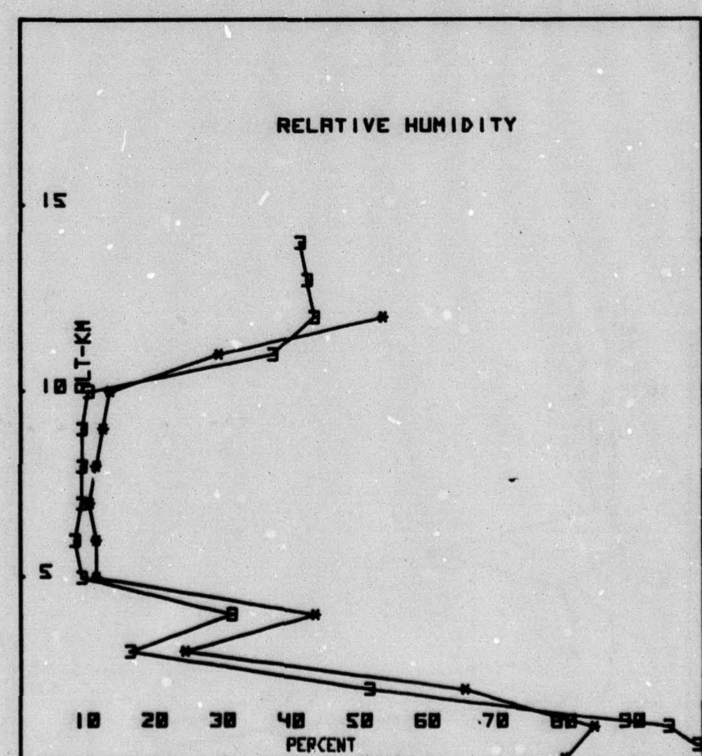


Figure 26. Flight 10; *-NWS rawinsonde; 3-NMSS standard duct without cork and cardboard, night flight.

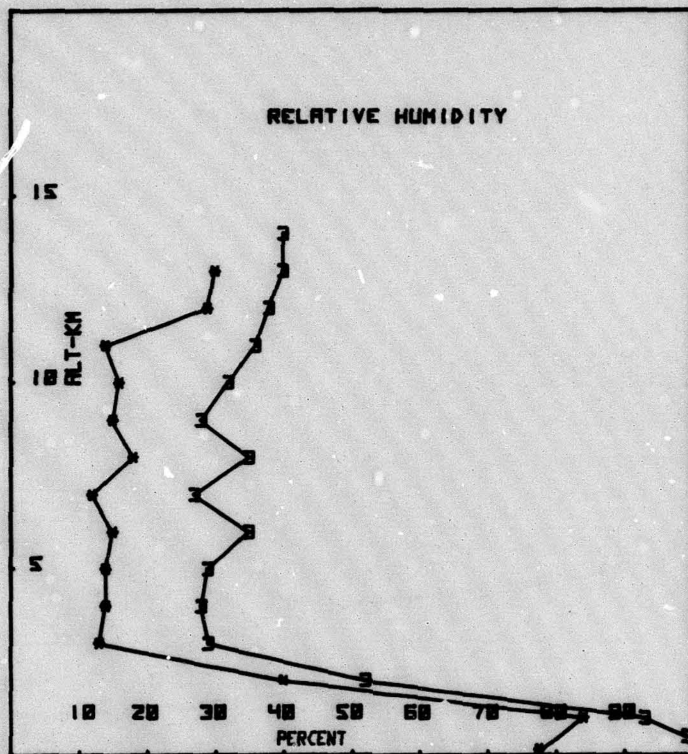


Figure 27. Flight 12; *-NWS rawinsonde; 3-NWS standard duct, without cork or shielding.

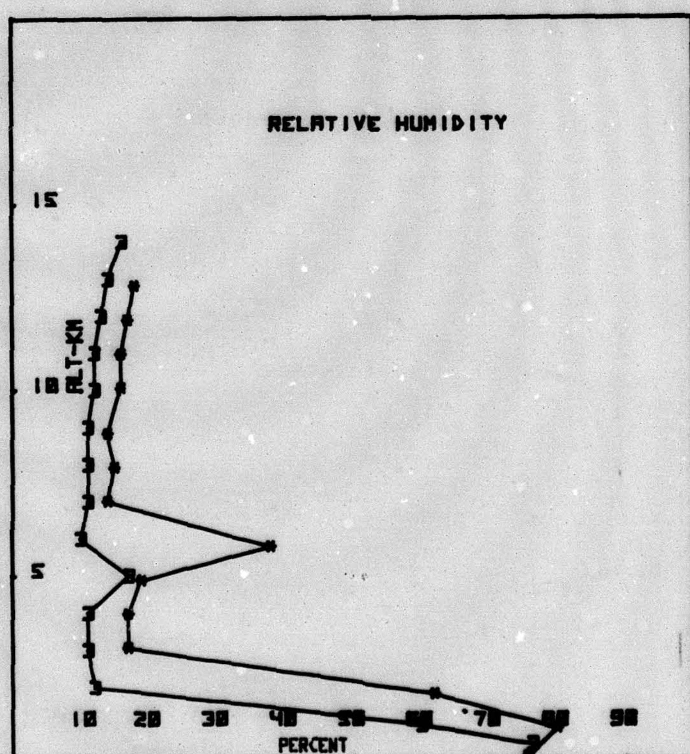


Figure 28. Flight 19; *-NWS rawinsonde; 3-Standard duct without cork or insulation.

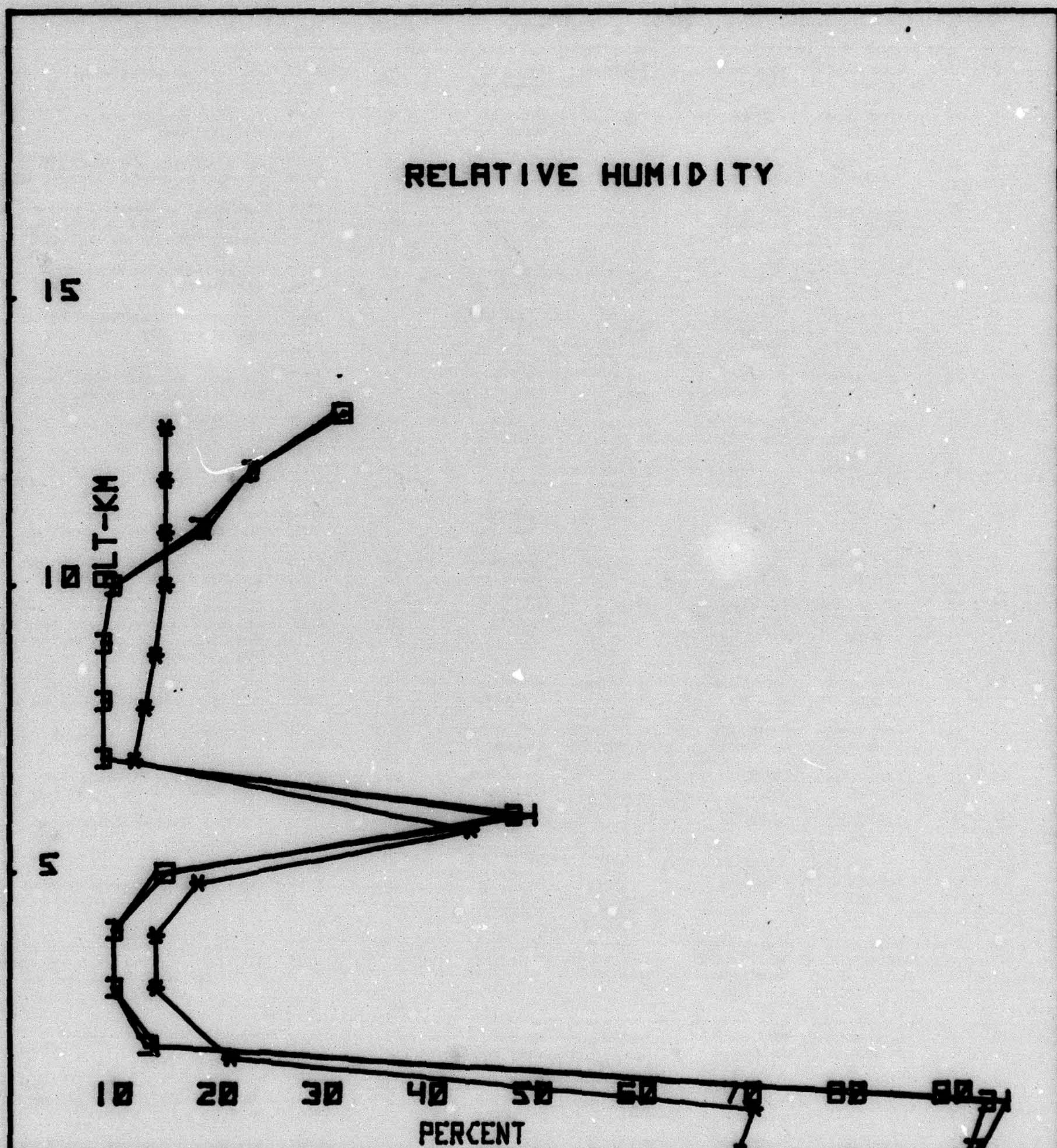


Figure 29. Flight 21; *-NWS rawinsonde; 1-RMSS standard duct on standoff, with shielding; 3-NWS duct mounted on side of RMSS case.

TABLE 1. RMSS RADIOSONDE FLIGHT TESTS

Flight No.	SN	Channel 1	Channel 2	Channel 3	Channel 4	Date (1978) Jan	Time	Remarks
0	1	Loop mount on boom	100K Resistor	Hygristor	Hygristor thermistor	18 18	2220Z 1020L	Std configuration with no modifications.
1	72	Loop mount on boom	100K Resistor	Hygristor	Hygristor thermistor	20 19	0130Z 1330L	Std configuration with no modifications.
2	10	Loop mount on boom	Std duct wall temp	Std duct temp	Add-on std duct temp	20 20	2020Z 0820L	Std sonde with additional std. Std duct adjacent to existing duct.
3	33	Loop mount on boom	Std duct wall temp	Std duct temp	Add-on std duct temp	21 20	0134Z 1334L	Configuration identical to previous flight, but with 6 mm cork between battery and adjacent duct wall.
4	62	Loop mount on boom	100K Resistor	Hygristor	Hygristor thermistor	21 21	2315Z 1115L	Std configuration flown at -35° angle.
5	48	Loop mount on boom	Thermistor at std duct entrance	Std duct temp	Add-on std duct temp	22 21	0332Z 1532L	Std sonde with additional std duct, both at -35° angle.
6	82	Loop mount on boom	C3 inlet thermistor	Std duct temp	C3 duct temp	22 22	2359Z 1159L	Std sonde with additional Krumins both flown at -45° angle.
7	36	Hygristor in std duct	Hygristor thermistor	Hygristor in C3 duct	Hygristor thermistor	23 22	0413Z 1617L	Std sonde at 0° angle plus C3 duct at -45° angle.
8	56	Loop mount on boom	C3 inlet thermistor	Std duct temp	C3 duct temp	23 23	2123Z 0923L	Std sonde plus add-on std duct at -35° plus C3 duct at -45°.
9	45	Loop mount on boom	YSI 44006 on boom	Hygristor	Hygristor thermistor	24 23	0105Z 1305L	Std sonde plus 2nd boom for evaluating YSI 44006 thermistor.
10	50	Loop mount on boom	YSI 44006 on boom	Hygristor	Hygristor thermistor	24 23	0730Z 1930L	Identical to previous flight but launched after dark.
11	52	YSI thermistor on Ch 1/2 IC commutator	YSI thermistor on Ch 3/4 IC commutator	Fixed resistor	Fixed resistor	24 24	1853Z 0653L	Diagnostic flight with YSI thermistors on two IC commutators plus two fixed resistors. Trying to find source of channel loss.
12	58	Loop mount on boom	Post mount on boom	Hygristor	Hygristor thermistor	24 24	2205Z 1005L	Std sonde plus 10-mil bead on post mount adjacent to loop mount.
13	42	Loop mount on boom 1	Sensi chip on boom 1	Wafer therm on boom 2	Western therm on boom 2	25 24	0203Z 1403L	Std sonde with two booms for four thermistors.
14	71	Loop mount on boom	Std duct temp	Standoff std duct temp	Standoff C3 duct temp	25 24	0515Z 1715L	Std sonde with additional std duct and C3 duct on 2-inch standoffs.
15	8	Loop mount on boom	Hygristor	Paralleled with Channel 2	Paralleled with Channel 1	25 24	0823Z 2023L	Std sonde with no modifications.
16	15	Loop mount on boom	Hygristor	Paralleled with Channel 2	Paralleled with Channel 1	26 26	2300Z 1100L	Std sonde with no modifications.
17	67	Loop mount on boom	Standoff duct w/post mount thermistor	Standoff duct inlet thermistor	Rod thermistor	27 26	0152Z 1352L	Std duct mounted on 2-in standoffs. Rod thermistor mounted on VIZ framework. Balloon burst at 19.2 km.
						Apr		
19	7	Loop mount on boom	Post mount on boom	Hygristor in std duct	NWS rod thermistor	6 6	2230Z 1030L	Channel 2 data not usable.
20	68	Loop mount on boom	Standoff duct hygristor	Std duct hygristor	Standoff duct hygristor thermistor	7 6	0208Z 1408L	Bad ranging; interference between J005 and RMSS; both payloads on same balloon train.
21	57	Hygristor standoff duct	Hygristor thermistor in standoff duct	Hygristor in J005 duct	Hygristor thermistor in J005 duct	7 6	0411Z 1611	J005 duct mounted beside RMSS sonde. Cardboard solar shielding in standoff duct.
22		Loop mount on boom	Post mount on boom	Hygristor in std duct	NWS rod thermistor	7	0857	Nighttime release.

Note: Flight 18 was a standard sonde configuration released for ground equipment test.

TABLE 2. THERMISTORS

Mfg	Type	Size (mm)	Remarks
VEECO	Bead 35A5/7	0.25 (10 mil)	Aluminized; used on loop mount and post mount
VEECO	Wafer 35SC1A604	1.8 x 1.8 x 1.3	Sensi chip, time constant 4 sec
YSI	Bead 44006	1.4 (55 mil)	
YSI	Wafer	2.9 x 1.3 x 0.8	Gold leads 0.05 x 2.9 mm. Same calibration as YSI 44006
Western	Bead PN1M5111-D	1.4 (55 mil)	
VIZ	Bead		Mounted on hygristor

APPENDIX

TABULATED DATA

KWAJALEIN MISSILE RANGE

RMSS RADIOSONDE TEST FLIGHT #1

ALT-KM	CH#1	CH#3	CH#4
1.0	19	81	20
2.0	16	35	18
3.0	13	17	15
4.0	6	16	7
5.0	0	15	1
6.0	-5	16	-3
7.0	-11	14	-9
8.0	-19	15	-17
9.0	-26	15	-24
10.0	-33	15	-31
12.0	-51	17	-47
13.0	-59	19	-55
14.0	-69	21	-65
15.0	999	999	999
16.0	999	999	999
17.0	999	999	999
18.0	999	999	999
19.0	999	999	999
20.0	-59	19	-54
21.0	-58	18	-49
22.0	-58	17	-45
23.0	-57	17	-43
24.0	-55	17	-41
25.0	-49	16	-36
26.0	-47	15	-32
27.0	-47	16	-29
28.0	-48	15	-26
29.0	-49	15	-24
30.0	-46	15	-22
31.0	-47	17	-19
32.0	-39	17	-14
33.0	-36	16	-12
34.0	-36	17	-10
35.0	-36	18	-8

999 DENOTES MISSING DATA

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #1

ALT-KM	TEMP,C	PRESS, MB	RH
0	29.6	1008.000	72
1	20.1	900.000	78
2	16.6	801.000	28
3	10.6	711.000	16
4	3.9	630.000	15
5	-1.3	557.000	14
6	-8.2	491.000	15
7	-13.1	431.000	16
8	-19.7	378.000	14
9	-26.7	330.000	14
10	-33.6	287.000	14
11	-41.7	248.000	15
12	-50.2	214.000	16
13	-58.5	183.000	17
14	-66.5	156.000	999
15	-74.7	132.000	999
16	-79.4	111.000	999
17	-83.6	92.800	999
18	-84.7	77.600	999
19	-80.4	64.800	999
20	-65.0	54.700	999
21	-60.2	46.600	999
22	-58.0	39.800	999
23	-58.3	34.000	999
24	-56.8	29.100	999
25	-53.6	24.900	999
26	-49.1	21.400	999
27	-48.1	18.400	999
28	-49.3	15.800	999
29	-50.1	13.600	999
30	-47.2	11.700	999
31	-43.3	10.100	999
32	-38.7	8.730	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #2

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.5	24	29	36	25
1.0	20	26	31	22
2.0	16	23	28	18
3.0	13	21	24	15
4.0	6	15	16	7
5.0	-1	11	8	0
6.0	-5	8	5	-3
7.0	-9	7	0	-7
8.0	-19	2	-10	-16
9.0	-26	-2	-17	-24
10.0	-34	-8	-26	-32
11.0	-41	-18	-33	-39
12.0	-50	-24	-42	-47
13.0	-57	-28	-50	-54
14.0	-65	-33	-58	-62
15.0	-73	-37	-67	-71
16.0	-79	-40	-73	-76
17.0	-82	-42	-75	-79
18.0	-84	-42	-77	-81
18.7	-87	-43	-81	-85
19.0	-82	-42	-76	-80
20.0	-65	-31	-58	-61
21.0	-63	-26	-55	-60
22.0	-60	-22	-51	-57
23.0	-59	-19	-47	-53
24.0	-50	-13	-40	-47
25.0	-49	-10	-34	-43
26.0	-47	-8	-32	-42

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #2

ALT-KM	TEMP,C	PRESS, MB	RH
0	28.0	1009.000	78
1	21.0	902.000	79
2	16.6	803.000	28
3	14.1	714.000	14
4	7.5	633.000	13
5	0.5	560.000	14
6	-3.0	494.000	13
7	-7.2	435.000	12
8	-15.8	382.000	13
9	-23.9	334.000	13
10	-31.1	291.000	14
11	-39.6	252.000	15
12	-46.8	218.000	15
13	-54.6	187.000	14
14	-62.7	160.000	999
15	-70.9	135.500	999
16	-78.6	114.000	999
17	-81.9	95.800	999
18	-84.3	80.200	999
19	-79.7	67.000	999
20	-63.8	56.600	999
21	-60.6	48.300	999
22	-58.8	41.200	999
23	-57.0	35.200	999
24	-55.9	30.100	999
25	-50.8	25.800	999
26	-49.3	22.200	999
27	-48.5	19.100	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #3

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.5	22	27	25	24
1.0	20	24	22	22
2.0	16	20	18	18
3.0	12	17	14	15
4.0	5	10	7	6
5.0	-2	4	0	0
6.0	-7	0	-4	-4
7.0	-12	-4	-10	-10
8.0	-19	-10	-16	-16
9.0	-27	-17	-24	-24
10.0	-34	-22	-30	-30
11.0	-42	-24	-39	-38
12.0	-52	-36	-48	-48
13.0	-57	-41	-53	-54
14.0	-66	-47	-62	-62
15.0	-73	-52	-69	-69
16.0	-81	-57	-74	-75
17.0	-85	-60	-80	-81
18.0	-89	-62	-83	-84
18.4	-90	-62	-85	-85
19.0	-84	-58	-83	-84
20.0	-65	-41	-60	-59
21.0	-63	-39	-58	-56
22.0	-61	-34	-51	-54
23.0	-57	-29	-46	-50
24.0	-54	-24	-42	-46
25.0	-52	-22	-39	-44
26.0	-52	-20	-40	-41
27.0	-53	-16	-39	-43

999 DENOTES MISSING DATA

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #3

ALT-KM	TEMP,C	PRESS, MB	RH
0	30.0	1009.000	69
1	20.6	901.000	61
2	16.5	802.000	41
3	14.1	713.000	17
4	7.5	633.000	18
5	-0.1	560.000	19
6	-4.1	494.000	18
7	-8.5	435.000	18
8	-16.8	382.000	18
9	-24.3	334.000	18
10	-31.3	291.000	19
11	-39.0	252.000	22
12	-47.2	217.000	24
13	-54.8	187.000	24
14	-63.2	159.000	999
15	-71.4	135.000	999
16	-79.3	114.000	999
17	-84.0	95.400	999
18	-86.5	79.700	999
19	-79.4	66.600	999
20.	-64.2	56.400	999
21	-61.8	48.000	999
22	-58.0	40.900	999
23	-58.5	35.000	999
24	-53.7	29.900	999
25	-51.6	25.700	999
26	-50.2	22.100	999
27	-50.3	19.000	999
28	-51.6	16.300	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #4

ALT-KM	CH#1	CH#3	CH#4
0.5	23	90	26
1.0	17	88	21
2.0	12	85	16
3.0	10	34	13
4.0	6	36	9
5.0	-1	29	2
6.0	-6	30	-2
7.0	-11	30	-7
8.0	-19	29	-14
9.0	-26	29	-21
10.0	-32	30	-26
11.0	-37	24	-32
12.0	-48	43	-42
13.0	-58	42	-51
14.0	-69	41	-62
15.0	-79	41	-69
16.0	-86	41	-69
16.7	-90	40	-69
17.0	-88	40	-69
18.0	-80	40	-69
19.0	-71	40	-68
20.0	-70	40	-57
21.0	-59	38	-46
22.0	-58	35	-43
23.0	-59	34	-41
24.0	-57	34	-39
25.0	-55	34	-34

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #4

ALT-KM	TEMP,C	PRESS, MB	RH
0	29.6	1010.000	71
1	20.1	903.000	80
2	15.6	804.000	67
3	12.9	714.000	12
4	7.3	633.000	14
5	1.0	560.000	10
6	-3.2	494.000	10
7	-9.5	435.000	10
8	-15.9	382.000	10
9	-22.9	334.000	10
10	-29.4	291.000	10
11	-38.4	253.000	16
12	-46.3	218.000	20
13	-54.7	187.000	20
14	-63.0	160.000	999
15	-71.4	136.000	999
16	-80.4	114.000	999
17	-87.7	95.500	999
18	-82.8	79.700	999
19	-79.1	67.000	999
20	-68.3	56.600	999
21	-60.3	48.100	999
22	-57.1	41.100	999
23	-56.6	35.200	999
24	-56.2	30.100	999
25	-54.3	25.700	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #5

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.5	21	19	25	19
1.0	19	17	21	16
2.0	15	13	17	11
3.0	11	8	14	5
4.0	7	5	10	2
5.0	0	-2	2	-6
6.0	-3	-6	0	-9
7.0	-9	-11	-6	-15
8.0	-13	-16	-9	-20
9.0	-22	-24	-18	-27
10.0	-32	-34	-30	-36
11.0	-41	-44	-38	-44
12.0	-51	-54	-48	-53
13.0	-60	-63	-59	-59
14.0	-67	-70	-65	-64
15.0	-78	-77	-72	-71
16.0	-86	-81	-81	-75
16.8	-88	-89	-87	-78
17.0	-87	-82	-78	-75
18.0	-80	-76	-75	-72
19.0	-68	-64	-59	-64
20.0	-67	-63	-57	-63
21.0	-60	-53	-45	-56
22.0	-60	-61	-55	-57
23.0	-59	-51	-49	-55
24.0	-56	-55	-41	-54
25.0	-53	-43	-35	-50
26.0	-53	-37	-33	-45
27.0	-50	-41	-29	-47
28.0	-46	-38	-36	-46
29.0	-46	-32	-19	-43
30.0	-42	-35	-30	-42
31.0	-40	-41	-26	-40
32.0	-40	-35	-28	-41
33.0	-37	-39	-25	-40
34.0	-34	-30	-13	-35
35.0	-29	-30	-18	-35

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #5

ALT-KM	TEMP,C	PRESS, MB	RH
0	28.8	1007.000	72
1	19.7	900.000	89
2	16.8	801.000	54
3	12.0	712.000	71
4	8.0	632.000	18
5	1.3	559.000	12
6	-3.1	493.000	11
7	-9.0	434.000	11
8	-15.7	381.000	11
9	-22.3	334.000	12
10	-30.3	291.000	13
11	-37.4	252.000	15
12	-45.6	218.000	21
13	-53.4	187.000	23
14	-61.6	160.000	999
15	-70.6	136.000	999
16	-78.3	115.000	999
17	-86.5	95.900	999
18	-87.5	79.900	999
19	-78.2	67.000	999
20	-68.1	56.500	999
21	-63.8	48.000	999
22	-60.1	40.900	999
23	-59.6	34.900	999
24	-57.1	29.800	999
25	-52.7	25.500	999
26	-53.8	21.900	999
27	-52.2	18.800	999
28	-49.5	16.100	999
29	-46.8	13.900	999
30	-44.4	12.000	999
31	-42.8	10.300	999
32	-42.7	8.920	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #6

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.5	23	25	28	23
1.0	19	23	24	21
2.0	15	19	20	17
3.0	10	14	16	11
4.0	6	11	11	7
5.0	1	6	5	2
6.0	-2	3	4	0
7.0	-10	-6	-5	-8
8.0	-18	-14	-12	-16
9.0	-25	-21	-17	-22
10.0	-32	-29	-25	-30
11.0	-40	-36	-36	-37
12.0	-47	-43	-38	-42
13.0	-55	-53	-51	-52
14.0	-64	-63	-49	-49
15.0	-70	-67	-55	-52
16.0	-87	-87	999	-35
17.0	-88	-82	999	999
18.0	-81	-77	999	999
19.0	-81	-77	999	999
20.0	-69	-63	-55	999
21.0	-63	-61	-50	999
22.0	-59	-54	999	999
23.0	-58	-56	-44	999
24.0	-57	-48	999	999
25.0	-55	-52	999	999
26.0	-52	-50	999	999
27.0	-46	-45	999	999

999 DENOTES MISSING DATA

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #6

ALT-KM	TEMP,C	PRESS, MB	RH
0	31.8	1009.000	74
1	19.8	901.000	99
2	15.9	803.000	97
3	11.8	713.000	63
4	6.6	633.000	79
5	1.6	560.000	75
6	-3.0	494.000	9
7	-10.1	435.000	9
8	-16.7	382.000	10
9	-23.2	334.000	10
10	-31.0	291.000	11
11	-39.4	252.000	12
12	-46.3	218.000	12
13	-54.3	187.000	13
14	-62.9	160.000	999
15	-71.4	135.000	999
16	-78.7	114.000	999
17	-86.8	95.500	999
18	-83.9	79.600	999
19	-80.1	66.800	999
20	-69.6	56.300	999
21	-62.0	47.900	999
22	-59.2	40.800	999
23	-58.0	34.900	999
24	-57.6	29.800	999
25	-56.9	25.500	999
26	-53.3	21.800	999
27	-51.8	18.700	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #7

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.5	100	26	101	26
1.0	97	24	97	24
2.0	84	20	84	20
3.0	48	16	48	16
4.0	22	10	24	10
5.0	94	3	87	3
6.0	8	1	11	0
7.0	8	-5	11	-6
8.0	8	-12	12	-13
9.0	8	-20	12	-21
10.0	15	-29	25	-29
11.0	22	-38	32	-38
12.0	17	-47	54	-48
13.0	21	-60	51	-60
14.0	22	-72	28	-15
15.0	23	-79	29	-16
16.0	23	-85	30	-57
17.0	24	-87	31	-84
18.0	23	-84	30	-81
19.0	23	-78	30	-77
20.0	20	-67	29	-67
21.0	18	-60	27	-62
22.0	16	-59	26	-61
23.0	15	-55	25	-56
24.0	13	-50	23	-51
25.0	12	-46	18	-47
26.0	11	-42	16	-45
27.0	17	-37	15	-42
28.0	9	-32	14	-38
29.0	9	-29	14	-34
30.0	8	-27	14	-33
31.0	8	-25	13	-29
32.0	8	-21	13	-25
33.0	8	-18	12	-23
34.0	8	-17	12	-22
35.0	8	-15	13	-21
36.0	8	-13	12	-20
37.0	8	-13	12	-19

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #7

ALT-KM	TEMP,C	PRESS, MB	RH
0	27.5	1006.000	78
1	19.3	898.000	95
2	16.0	800.000	77
3	11.8	711.000	46
4	5.3	630.000	27
5	-1.4	557.000	85
6	-3.7	492.000	9
7	-11.3	433.000	10
8	-17.7	379.000	10
9	-24.1	332.000	11
10	-31.8	289.000	11
11	-39.8	250.000	7
12	-47.2	216.000	14
13	-54.7	185.000	15
14	-63.3	158.000	999
15	-71.4	134.000	999
16	-79.2	113.000	999
17	-87.8	94.600	999
18	-84.0	78.800	999
19	-80.9	66.000	999
20	-72.4	55.600	999
21	-64.6	47.200	999
22	-61.7	40.200	999
23	-61.3	34.200	999
24	-58.6	29.200	999
25	-56.1	24.990	999
26	-53.4	21.400	999
27	-51.5	18.400	999
28	-49.5	15.800	999
29	-47.7	13.600	999
30	-46.4	11.700	999
31	-45.0	10.100	999
32	-44.2	8.700	999
33	-39.6	7.520	999
34	-39.3	6.510	999
35	-39.3	5.640	999
36	-39.5	4.880	999
37	-38.7	4.230	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #8

ALT-KM	CH#1	CH#3	CH#4
1.0	17	21	21
2.0	14	17	17
3.0	10	13	13
4.0	4	8	6
5.0	0	3	2
6.0	-6	-3	-3
7.0	-12	-9	-9
8.0	-18	-15	-16
9.0	-24	-20	-21
10.0	-34	-30	-30
11.0	-42	-39	-39
12.0	-51	-46	-48
13.0	-60	-57	-57
14.0	-69	-63	-64
15.0	-76	-71	-71
16.0	-84	-78	-79
16.8	-91	-87	-85
17.0	-91	-82	-81
18.0	-85	-77	-85
19.0	999	-66	-67
20.0	999	-60	-63
21.0	-65	-53	-49
22.0	-61	-49	-50
23.0	-56	-51	-47
24.0	-58	-46	-44
25.0	-54	-46	-47
26.0	-54	-45	-42
27.0	-52	-48	-40
28.0	-50	-44	-36
29.0	-46	-37	-32
30.0	-44	-34	-31
31.0	-45	-31	-24
32.0	-45	-36	-23
33.0	-42	-30	-25
34.0	-38	-30	-19
35.0	-37	-14	-19
36.0	-31	-15	-15

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #8

ALT-KM	TEMP,C	PRESS, MB	RH
0	31.1	1009.000	75
1	21.2	902.000	83
2	17.1	803.000	78
3	12.7	714.000	48
4	6.6	634.000	43
5	2.3	561.000	30
6	-3.0	495.000	10
7	-8.4	436.000	9
8	-15.2	383.000	10
9	-21.0	335.000	10
10	-29.1	292.000	11
11	-37.2	254.000	48
12	-45.6	219.000	50
13	-54.4	188.000	51
14	-63.1	161.000	999
15	-71.3	136.000	999
16	-78.5	115.000	999
17	-87.5	96.200	999
18	-82.4	80.200	999
19	-77.3	67.200	999
20	-67.2	56.800	999
21	-64.6	48.300	999
22	-61.7	41.100	999
23	-58.8	35.100	999
24	-56.2	30.000	999
25	-55.6	25.700	999
26	-52.7	22.000	999
27	-51.4	18.900	999
28	-49.1	16.200	999
29	-45.6	14.000	999
30	-43.7	12.100	999
31	-42.9	10.400	999
32	-41.7	8.990	999
33	-41.9	7.770	999
34	-39.9	6.720	999
35	-37.4	5.820	999
36	-34.0	5.050	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #9

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.5	23	25	93	27
1.0	18	21	91	23
2.0	15	18	44	21
3.0	10	13	28	16
4.0	4	7	51	10
5.0	0	3	10	6
6.0	-6	-4	10	0
7.0	-12	-10	10	-6
8.0	-19	-17	10	-13
9.0	-25	-23	11	-20
10.0	-34	-32	11	-30
11.0	-42	-39	25	-39
12.0	-50	-48	28	-49
13.0	-59	-57	28	-59
14.0	-68	-66	28	-69
15.0	-75	-73	29	-74
16.0	-83	-78	30	-76
16.5	-86	999	28	999
17.0	-89	999	999	999
18.4	-85	-77	999	999
19.0	-70	-68	999	999
20.0	-67	-63	999	999
21.0	-66	-61	999	999
22.0	-63	-57	999	999
23.0	-59	-55	999	999
24.0	-59	-54	999	999
25.0	-57	-52	999	999
26.0	-54	-48	999	999
27.0	-51	-44	999	999
28.0	-47	-41	999	999
29.0	-46	-39	999	999
30.0	-44	-37	999	999
31.0	-45	-37	999	999
32.0	-44	-35	999	999
33.0	-43	-34	999	999
34.0	-38	-30	999	999

999 DENOTES MISSING DATA

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #9

ALT-KM	TEMP,C	PRESS, MB	RH
0	29.4	1008.000	71
1	19.8	900.000	83
2	16.4	801.000	43
3	11.9	712.000	41
4	6.3	631.000	38
5	1.7	559.000	12
6	-4.0	493.000	11
7	-9.9	434.000	11
8	-16.6	381.000	12
9	-23.1	333.000	11
10	-30.4	290.000	12
11	-38.5	252.000	21
12	-46.2	217.000	23
13	-55.0	187.000	24
14	-63.3	159.000	999
15	-70.6	135.000	999
16	-78.7	114.000	999
17	-86.5	95.300	999
18	-84.7	79.500	999
19	-74.3	66.700	999
20	-69.0	56.500	999
21	-64.5	47.900	999
22	-61.6	40.800	999
23	-60.2	34.800	999
24	-58.1	29.700	999
25	-55.2	25.400	999
26	-54.1	21.800	999
27	-50.9	18.700	999
28	-46.1	16.100	999
29	-42.3	13.900	999
30	-43.2	12.000	999
30	-44.6	10.300	999
32	-44.8	8.920	999
33	-40.8	7.700	999
34	-37.7	6.670	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #10

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.5	23	24	99	26
1.0	20	21	95	23
2.0	17	15	51	18
3.0	12	12	16	15
4.0	5	5	31	9
5.0	1	1	9	5
6.0	-3	-2	8	1
7.0	-10	-10	9	-6
8.0	-17	-17	9	-14
9.0	-24	-24	9	-22
10.0	-32	-32	10	-31
11.0	-40	-40	37	-40
12.0	-49	-48	43	-51
13.0	-58	-57	42	-61
14.0	-66	-66	41	-71
15.0	-75	-75	41	-79
16.0	-83	999	40	-85
17.0	-89	999	40	-89
17.2	-89	999	40	-89
18.0	-83	999	40	-86
19.0	-75	999	40	-81
20.0	-66	-68	38	-73
21.0	-66	-67	34	-69
22.0	-64	-65	33	-65
23.0	-60	-61	29	-61
24.0	-59	-60	29	-60
25.0	-54	-56	22	-52
26.0	-49	-52	16	-48
27.0	-47	-50	13	-42
28.0	-45	-48	12	-40
29.0	-45	-48	12	-35
30.0	-45	-48	12	-33
31.0	-44	-48	13	-31
32.0	-42	-46	13	-28
33.0	-40	-45	13	-27
34.0	-38	-43	15	-24

999 DENOTES MISSING DATA

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #10

ALT-KM	TEMP,C	PRESS, MB	RH
0	27.2	1008.000	79
1	20.2	900.000	84
2	16.1	801.000	65
3	12.1	711.000	24
4	6.3	631.000	43
5	1.7	558.000	11
6	-2.4	493.000	11
7	-9.9	434.000	10
8	-17.2	381.000	11
9	-23.7	333.000	12
10	-31.2	290.000	13
11	-39.3	251.000	29
12	-47.6	217.000	53
13	-56.1	186.000	999
14	-65.0	159.000	999
15	-73.7	134.000	999
16	-81.6	113.000	999
17	-89.8	94.300	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #12

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.5	20	22	99	23
1.0	17	20	93	20
2.0	13	16	52	16
3.0	10	12	29	13
4.0	5	7	28	8
5.0	0	2	29	2
6.0	-6	-3	35	-2
7.0	-11	-8	27	-7
8.0	-19	-16	35	-15
9.0	-26	-23	28	-22
10.0	-35	-32	32	-30
11.0	-43	-40	36	-38
12.0	-51	-48	38	-46
13.0	-60	-58	40	-46
14.0	-68	-66	40	-49
15.0	-77	-75	40	-54
16.0	-86	-84	40	-54
16.0	-86	-84	40	-57
17.0	-90	-88	40	-61
18.0	-81	-78	40	-57
19.0	-73	-71	999	999
20.0	-69	-67	999	999
21.0	-63	-60	999	999
22.0	-65	-63	999	999
23.0	-63	-61	999	999
24.0	-58	-56	999	999
25.0	-55	-53	999	999
26.0	-52	-49	999	999
27.0	-49	-47	999	999
28.0	-50	-47	999	999
29.0	-49	-44	999	999
30.0	-42	-40	999	999
31.0	-43	-40	999	999

999 DENOTES MISSING DATA

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #12

ALT-KM	TEMP,C	PRESS, MB	RH
0	28.1	1009.000	77
1	19.7	901.000	84
2	16.1	802.000	40
3	13.1	713.000	13
4	8.0	632.000	14
5	2.6	559.000	14
6	-3.6	494.000	15
7	-8.2	435.000	12
8	-15.8	382.000	18
9	-22.4	334.000	15
10	-30.3	291.000	16
11	-38.6	253.000	14
12	-45.9	218.000	29
13	-54.5	187.000	30
14	-63.6	160.000	999
15	-71.5	136.000	999
16	-80.0	114.000	999
17	-86.8	95.400	999
18	-81.6	79.700	999
19	-75.6	66.900	999
20	-67.0	56.600	999
21	-64.2	48.100	999
22	-63.5	40.900	999
23	-61.0	34.900	999
24	-58.8	29.740	999
25	-54.5	25.500	999
26	-52.7	21.800	999
27	-49.8	18.700	999
28	-48.8	16.100	999
29	-48.4	13.900	999
30	-44.0	12.000	999
31	-44.2	10.300	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #13

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.5	23	23	24	23
1.0	20	20	22	20
2.0	16	16	17	16
3.0	13	13	14	13
4.0	7	8	8	7
5.0	1	2	2	1
6.0	-2	-1	-1	-1
7.0	-8	-7	-7	-8
8.0	-16	-15	-15	-15
9.0	-23	-22	-23	-22
10.0	-31	-29	-30	-30
11.0	-39	-38	-39	-38
12.0	-48	-45	-47	-45
13.0	-57	-54	-55	-54
14.0	-65	-62	-63	-62
15.0	-73	-69	-71	-69
25.0	-53	-46	999	999
26.0	-50	-44	999	999
27.0	-47	-40	99	999
28.0	-45	-37	-36	-40
29.0	-47	-38	-34	-38
30.0	-42	-34	999	999

999 DENOTES MISSING DATA

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #13

ALT-KM	TEMP,C	PRESS, MB	RH
0	29.5	1007.000	72
1	19.4	899.000	87
2	15.2	800.000	36
3	12.4	711.000	18
4	6.4	630.000	19
5	1.6	558.000	21
6	-3.3	492.000	21
7	-9.2	434.000	15
8	-16.3	380.000	17
9	-23.6	333.000	16
10	-30.6	290.000	31
11	-38.2	251.000	52
12	-46.7	217.000	58
13	-55.1	186.000	53
14	-63.2	159.000	999
15	-72.2	135.000	999
16	-80.0	113.000	999
17	-86.3	94.900	999
18	-83.8	79.000	999
19	-76.0	66.500	999
20	-69.9	56.200	999
21	-64.3	47.600	999
22	-66.6	40.500	999
23	-61.5	34.400	999
24	-58.9	29.400	999
25	-55.0	25.100	999
26	-50.8	21.600	999
27	-49.5	18.500	999
28	-47.6	16.000	999
29	-47.8	13.700	999
30	-45.0	11.800	999
31	-47.0	10.200	999
32	-46.3	8.790	999
33	-42.1	7.580	999
34	-38.5	6.560	999
35	-38.1	5.690	999
36	-37.3	4.930	999
37	-35.5	4.270	999
38	-32.9	3.710	999
39	-32.7	3.230	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #14

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.5	20	26	23	30
1.0	16	22	18	26
3.0	9	15	12	19
4.0	5	11	7	15
5.0	0	6	3	10
6.0	-5	0	-3	3
7.0	-11	-5	-8	-2
8.0	-18	-12	-16	-10
9.0	-25	-18	-22	-16
10.0	-32	-26	-29	-23
11.0	-41	-35	-38	-33
12.0	-48	-42	-46	-41
13.0	-57	-50	-54	-49
14.0	-66	-59	-63	-59
15.0	-75	-69	-72	-68
16.0	-84	-78	-80	-76
16.7	-91	-85	-90	-84
17.0	-91	-84	-88	-83
18.0	-91	-90	-90	-69
19.0	-75	-69	-74	-69
20.0	-75	-66	-73	-66
21.0	-68	-63	-44	-61

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #14

ALT-KM	TEMP,C	PRESS, MB	RH
0	28.5	1006.000	69
1	19.7	898.000	83
2	15.9	799.000	40
3	12.5	710.000	15
4	8.0	630.000	21
5	2.9	558.000	31
6	-3.6	493.000	74
7	-8.5	434.000	15
8	-16.2	381.000	18
9	-22.6	333.000	12
10	-29.8	290.000	20
11	-38.0	252.000	65
12	-46.0	218.000	68
13	-54.3	187.000	52
14	-62.8	160.000	999
15	-72.0	135.000	999
16	-79.0	114.000	999
17	-86.1	95.400	999
18	-85.5	79.600	999
19	-78.3	66.600	999
20	-70.6	56.300	999
21	-66.4	47.600	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #17

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.5	22	22	21	22
1.0	19	20	19	19
2.0	16	17	16	17
3.0	11	11	11	11
4.0	6	6	6	6
5.0	0	1	1	1
6.0	-5	-4	-5	-4
7.0	-11	-10	-10	-10
8.0	-17	-16	-16	-16
9.0	-24	-23	-23	-23
10.0	-32	-30	-31	-31
11.0	-41	-39	-40	-40
12.0	-48	-47	-46	-48
13.0	-57	-55	-54	-55
14.0	-66	-63	-63	-64
15.0	-74	-72	-68	-69
16.0	-81	-78	-73	-77
17.0	-86	-83	-79	-80
18.0	-87	-85	-83	-83
19.0	-71	-68	-66	-68
19.2	-67	-65	-63	-65

CONJUNCTIVE RAWINSONDE FOR RMSS FLIGHT #17

ALT-KM	TEMP,C	PRESS, MB	RH
0	29.4	1007.000	67
1	19.9	899.000	81
2	17.7	800.000	19
3	12.5	712.000	48
4	6.8	631.000	35
5	1.9	559.000	10
6	-3.5	493.000	9
7	-9.8	434.000	10
8	-15.7	381.000	10
9	-22.4	333.000	14
10	-29.1	291.000	15
11	-38.0	252.000	17
12	-46.1	218.000	19
13	-54.4	187.000	19
14	-62.8	160.000	999
15	-70.7	136.000	999
16	-78.4	114.000	999
17	-83.5	95.700	999
18	-88.4	79.900	999
19	-74.1	66.800	999

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #19

ALT-KM	CH#1	CH#3	CH#4
0.5	26	76	26
1.0	22	60	22
2.0	21	12	21
3.0	17	11	16
4.0	7	11	10
5.0	2	17	5
6.0	-4	10	-2
7.0	-9	11	-6
8.0	-17	11	-14
9.0	-24	11	-21
10.0	-31	12	-29
11.0	-40	12	-38
12.0	-49	13	-46
13.0	-57	14	-54
14.0	-66	16	-63
15.0	-74	16	-71
16.0	-79	18	-77
17.0	-80	18	-78
18.0	-83	19	-80
19.0	-75	17	-74
20.0	-63	15	-61
21.0	-62	15	-59
22.0	-61	14	-58
23.0	-57	14	-55
24.0	-56	14	-53
25.0	-52	13	-50
26.0	-46	13	-43
27.0	-46	12	-43
28.0	-46	13	-43
29.0	-43	12	-41
30.0	-41	12	-39
31.0	-38	12	-37
32.0	-38	12	-36
33.0	-39	12	-36
33.6	-32	14	-34

RMSS RADIOSONDE TEST FLIGHT #20

ALT-KM	CH#1	CH#2	CH#3	CH#4
1.2	23	64	67	23
1.3	19	65	68	20
1.6	19	44	47	20
1.8	18	29	31	19
2.1	18	23	26	19
2.9	18	14	18	17
3.1	17	13	16	16
3.3	16	9	11	15
5.7	999	55	999	999
6.2	999	66	58	999
6.4	-2	54	59	-2
6.5	-4	48	56	999
6.8	999	999	999	999
7.8	-14	4	6	-14
8.4	-18	2	5	-18
9.3	-26	7	8	-24
9.5	-28	11	17	-25
9.7	-29	15	22	-26
9.8	-31	15	22	-27
9.9	-32	16	22	-28
10.1	-34	16	23	-30
10.8	-37	18	24	-34
11.8	-45	0	3	-43
12.4	-51	7	10	-47
12.5	-52	14	22	-49
12.7	-54	17	24	-50
12.8	-55	19	24	-52

999 DENOTES MISSING DATA

RMSS RADIOSONDE TEST FLIGHT #21

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.0	92	26	91	25
1.0	95	20	93	20
2.0	14	17	13	16
3.0	10	14	10	13
4.0	10	8	10	8
5.0	14	2	15	2
6.0	50	-3	48	-3
7.0	9	-9	9	[illegible]
8.0	9	-16	9	-16
9.0	9	-23	9	-23
10.0	10	-32	10	-32
11.0	19	-38	18	-38
12.0	23	-48	23	-48
13.0	31	-56	32	-56

RMSS RADIOSONDE TEST FLIGHT #22

ALT-KM	CH#1	CH#2	CH#3	CH#4
0.0	21	24	90	26
1.0	16	20	73	21
2.0	12	15	90	17
3.0	10	13	14	15
4.0	5	7	14	10
5.0	0	2	15	4
6.0	-6	-3	13	1
7.0	-12	-9	11	-6
8.0	-19	-16	11	-14
9.0	-26	-23	13	-21
10.1	-33	-30	80	-28
11.0	-38	-35	42	-33
12.0	-44	-42	39	-40
13.0	-52	-49	40	-47
14.0	-59	-57	35	-55
15.2	-65	-62	37	-61
16.3	-72	-69	37	-68
17.4	-80	-77	37	-75
18.4	-86	-83	37	-82
19.8	-84	-81	37	-80
20.4	-78	-75	37	-74
21.3	-68	-65	37	-65
22.4	-69	-66	36	-65
23.4	-63	-62	36	-60
24.5	-60	-58	34	-57
25.5	-53	-50	32	-51
26.7	-49	-47	28	-46
27.8	-51	-48	26	-47
29.0	-51	-49	25	-48
30.1	-49	-46	24	-47
31.2	-45	-43	25	-42
32.3	-45	-42	24	-42
33.4	-43	-41	14	-41
34.5	-41	-40	24	-39
35.6	-42	-41	27	-40
36.7	-36	-36	27	-34
37.8	-30	-32	26	-29

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44. Ballard, Harold N., "Temperature Measurements in the Stratosphere from Balloon-Borne Instrument Platforms, 1968-1975," ECOM-5808, December 1976.
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48. Bonner, Robert S., and R. Newton, "Application of the AN/GVS-5 Laser Rangefinder to Cloud Base Height Measurements," ECOM-5812, February 1977.
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53. Rubio, Roberto, and Mike Izquierdo, "Measurements of Net Atmospheric Irradiance in the 0.7- to 2.8-Micrometer Infrared Region," ECOM-5817, May 1977.

54. Ballard, Harold N., Jose M. Serna, and Frank P. Hudson Consultant for Chemical Kinetics, "Calculation of Selected Atmospheric Composition Parameters for the Mid-Latitude, September Stratosphere," ECOM-5818, May 1977.

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56. White, Kenneth O., Wendell R. Watkins, Stuart A. Schleusener, and Ronald L. Johnson, "Solid-State Laser Wavelength Identification Using a Reference Absorber," ECOM-5820, June 1977.

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75. White, Kenneth O. et al, "Water Vapor Continuum Absorption in the 3.5µm to 4.0µm Region," ASL-TR-0004, March 1978.

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87. Jennings, S.G., and R.G. Pinnick, "Effects of Particulate Complex Refractive Index and Particle Size Distribution Variations on Atmospheric Extinction and Absorption for Visible Through Middle-Infrared Wavelengths," ASL-TR-0016, September 1978.

88. Watkins, Wendell R., Kenneth O. White, Lanny R. Bower, and Brian Z. Sojka, " Pressure Dependence of the Water Vapor Continuum Absorption in the 3.5- to 4.0-Micrometer Region," ASL-TR-0017, September 1978.

8[illegible]. [illegible]ller, W.B., and B.F. Engebos, "Behavior of Four Sound Ranging Techniques in an Idealized Physical Enviroment," ASL-TR-0018, September 1978.

90. [illegible]ez, Richard G., "Effectiveness Studies of the CBU-88/B Bomb, Cluster, Smoke Weapon" (U), CONFIDENTIAL ASL-TR-0019, September 1978.

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93. Kennedy, Bruce W., Arthur Kinghorn, and B.R. Hixon, "Engineering Flight Tests of Range Meteorological Sounding System Radiosonde," ASL-TR-0022, February 1979.

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